AMERICAN MUSEUM
Novitates

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK, NY 10024
Number 3306, 30 pp., 13 figures, 1 table 13 December, 2000

Additions to the Ammonite Fauna of the Upper Cretaceous Navesink Formation of New Jersey

W. J. KENNEDY,[1] N. H. LANDMAN,[2] W. A. COBBAN,[3] AND R. O. JOHNSON[4]

ABSTRACT

New fossil collections provide additional information about the late Campanian and Maastrichtian ammonites from the Navesink Formation of New Jersey. Late Campanian ammonites include *Pseudophyllites indra* (Forbes, 1846), *Nostoceras* (*N.*) *approximans* (Conrad, 1855) (of which *Nostoceras* (*N.*) *stantoni* Hyatt, 1894, is a synonym), *Nostoceras* (*N.*) *hyatti* Stephenson, 1941, *Nostoceras* (*N.*) *pauper* (Whitfield, 1892), *Didymoceras* cf. *D. draconis* (Stephenson, 1941), *Exiteloceras rude* n. sp., *Hoploscaphites pumilus* (Stephenson, 1941), and *Jeletzkytes* cf. *J. nodosus* (Owen, 1852). Maastrichtian ammonites from the Navesink Formation include *Pachydiscus* (*P.*) *neubergicus neubergicus* (Hauer, 1858), *Kitchinites* sp., *Nostoceras* (*N.*) *alternatum* (Tuomey, 1854), *Baculites* sp., *Eubaculites* cf. *E. labyrinthicus* (Morton, 1834), *Eubaculites* sp.?, *Jeletzkytes* cf. *J. plenus* (Meek, 1876), *Jeletzkytes criptonodosus* Riccardi, 1983, and *Discoscaphites gulosus* (Morton, 1834).

These faunas are correlated with those of Western Europe, the Gulf Coast, and the Western Interior of the United States. The older fauna from the basal phosphatic beds of the Navesink Formation at the classic Atlantic Highlands locality is referred to the *Nostoceras* (*N.*) *hyatti* zone. It is late Campanian in age and equivalent to the *Nostoceras* (*N.*) *pozaryskii*/*Belemnella langei* zone in Europe and the *Baculites jenseni* zone in the United States Western Interior. In addition, these beds contain ammonites that range into the early Maastrichtian, as well as *Pachydiscus* (*P.*) *neubergicus*, whose appearance marks the base of the Maastrichtian. Thus, these phosphatic beds represent a condensed sequence that spans the late Campanian to early Maastrichtian. Ammonites also occur at other localities in the Navesink Formation in New Jersey, and correspond to higher levels in the Maastrichtian. The youngest ammonite known from the Navesink Formation, *Discoscaphites gulosus*, from Sewell, New Jersey, indicates a correlation with the *Hoploscaphites nicolletii* or *Jeletzkytes nebrascensis* zone of the Western Interior.

[1] Curator, Geological Collections, University Museum, Parks Road, Oxford OX1 3PW, United Kingdom.
[2] Curator, Division of Paleontology (Invertebrates), American Museum of Natural History.
[3] Research Associate, Division of Paleontology (Invertebrates), American Museum of Natural History.
[4] 57 Oceanport Ave., West Long Branch, New Jersey 07764-1427.

INTRODUCTION

The Navesink Formation (fig. 1) is a predominantly glauconitic unit that outcrops widely in New Jersey, notably on the coast at Atlantic Highlands (fig. 2), overlooking Sandy Hook Bay. At Atlantic Highlands, the Navesink Formation is about 7.6 m thick and rests with a marked unconformity on the underlying Mount Laurel Sand (fig. 1). The lower part of the Navesink is rich in phosphatic nodules, and these are the source of most of the fossils described herein. Ammonites from the basal part of the Navesink at this locality have been described by Say (1820), Whitfield (1892), and Prather (1905), and, most recently, by Cobban (1974a). The purpose of the present contribution is to update knowledge of the ammonites of this unit at Atlantic Highlands and elsewhere in New Jersey based on the analysis of extensive new collections, most of which were made in the last 20 years by members of the Monmouth Amateur Paleontologists Society, West Long Branch, New Jersey.

AGE OF THE NAVESINK AMMONITE FAUNAS

Phosphatic ammonites occur at two horizons in the basal part of the Navesink Formation at Atlantic Highlands. A lower layer, 15–20 cm thick and 0.7 m above the base of the Navesink, yields *Pseudophyllites indra* (Forbes, 1846), *Pachydiscus* (*P.*) *neubergicus neubergicus* (Hauer, 1858), *Kitchinites* sp., *Baculites ovatus* Say, 1820, *Baculites claviformis* Stephenson, 1941, *Nostoceras* (*N.*) *helicinum* (Shumard, 1861), *Nostoceras* (*N.*) *hyatti* Stephenson, 1941, *Nostoceras* (*N.*) *pauper* (Whitfield, 1892), *Nostoceras* (*N.*) *approximans* (Conrad, 1855), *Didymoceras* cf. *D. draconis* (Stephenson, 1941), *Axonoceras* cf. *A. angolanum* Haas, 1943, *Lewyites oronensis* (Lewy, 1969), *Cirroceras conradi* (Morton, 1841), *Hoploscaphites pumilus* (Stephenson, 1941), and *Jeletzkytes*

→

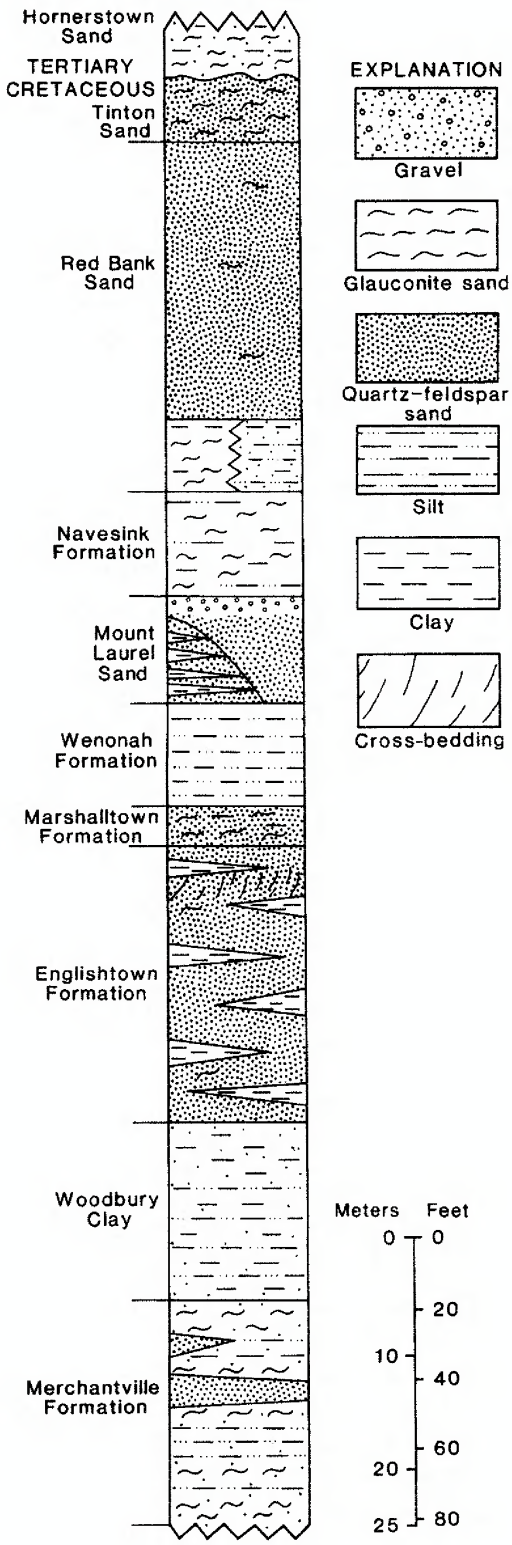


Fig. 1. Generalized stratigraphic succession for the Upper Cretaceous formations in the northern west-central coastal plain in New Jersey (modified after Owens et al., 1970).

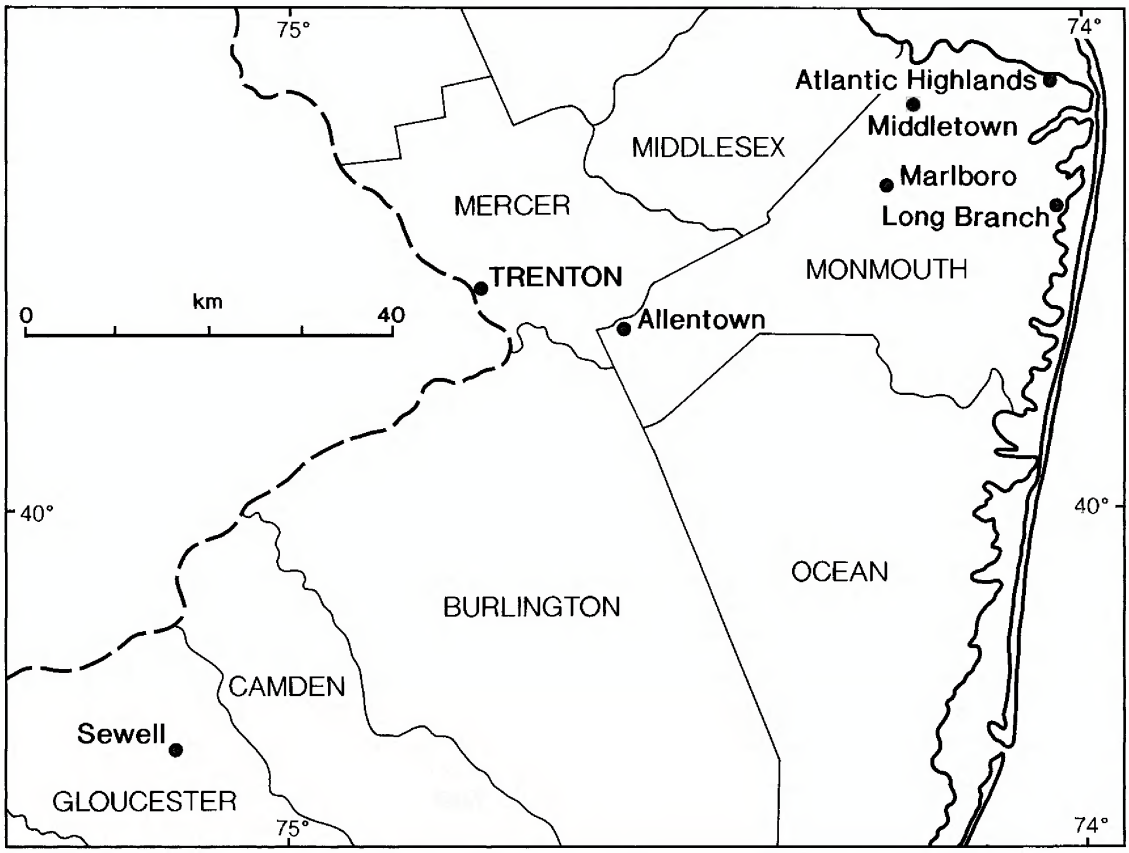


Fig. 2. Locality map for part of New Jersey showing localities where Navesink ammonites were collected.

cf. *J. nodosus* (Owen, 1852). The bulk of this fauna defines a *Nostoceras* (*N.*) *hyatti* zone (Kennedy and Cobban, 1993), as expressed in expanded sequences in the Gulf Coast and Europe. However, the presence of *Pachydiscus* (*P.*) *neubergicus neubergicus* indicates a minor Maastrichtian component, implying that the lower phosphatic bed is condensed.

A second layer at Atlantic Highlands, 0.2 m above the first and 12 cm thick, yields far fewer ammonites including *Nostoceras* (*N.*) *mendryki* Cobban, 1974a, which is also known from the Maastrichtian Prairie Bluff Chalk of Alabama (Cobban and Kennedy, 1995). A specimen of *Jeletzkytes* cf. *J. plenus* (Meek, 1876) is also probably from this layer.

The only other Maastrichtian ammonites from the Navesink Formation are a phosphatic specimen of *Nostoceras* (*N.*) *alternatum* (Tuomey, 1854), collected as float at Big Brook, near Marlboro, New Jersey; a phosphatic specimen of *Eubaculites* cf. *E. labyrinthicus* (Morton, 1834) from Crosswicks Creek, south of Allentown, Monmouth County; an unphosphatized specimen of *Jeletzkytes criptonodosus* Riccardi, 1983, from the middle of the Navesink Formation near Middletown, Monmouth County; some small baculitids and a specimen of *Discoscaphites gulosus* (Morton, 1834) from the Inversand Pit, Sewell, Gloucester County; and unpublished reports of fragmentary specimens of *Sphenodiscus lobatus* Tuomey, 1854, from the uppermost Navesink Formation at Crosswicks Creek, south of Allentown, Monmouth County.

Cobban (1974a) and Sugarman et al. (1995) reviewed the evidence for the position of the Campanian—Maastrichtian boundary

<table>
<tr><th>SUBSTAGE</th><th>BLASZKIEWICZ, 1980</th><th>CHRISTENSEN, 1975</th><th>SCHULZ, 1979; SCHULZ et al, 1984</th></tr>
<tr><td rowspan="6">LOWER MAASTRICHTIAN</td><td rowspan="3">Belemnella occidentalis</td><td rowspan="3">Belemnella occidentalis</td><td>Belemnella fastigata</td></tr>
<tr><td>Belemnella cimbrica</td></tr>
<tr><td>Belemnella sumensis</td></tr>
<tr><td rowspan="3">Belemnella lanceolata lanceolata</td><td rowspan="3">Belemnella lanceolata</td><td>Belemnella obtusa</td></tr>
<tr><td>Belemnella pseudobtusa</td></tr>
<tr><td>Belemnella lanceolata</td></tr>
<tr><td rowspan="6">UPPER CAMPANIAN</td><td>Nostoceras pozaryskii</td><td rowspan="2">Belemnella langei
+
Belemnitella minor</td><td>Micraster grimmensis / Cardiaster granulosus</td></tr>
<tr><td>Didymoceras donezianum</td><td>Belemnitella langei</td></tr>
<tr><td rowspan="2">Bostrychoceras polyplocum</td><td rowspan="4">Belemnitella minor</td><td>Bostrychoceras polyplocum</td></tr>
<tr><td>Galerites vulgaris</td></tr>
<tr><td rowspan="2">Neancyloceras phaleratum</td><td>Pachydiscus stobaei / Galeola papillosa</td></tr>
<tr><td>Echinocorys conica / B. mucronata senior</td></tr>
</table>

Fig. 3. Campanian-Maastrichtian macrofossil zonal successions in northwest Europe.

in the Atlantic Coastal Plain succession. This question depends, of course, on the fossil criteria used to define the boundary, that is, whether it is based on planktonic foraminifera, calcareous nannoplankton, or various macrofossils (see review in Olsson, 1988).

The placement of the boundary also depends on the choice of stratigraphic sections studied. Sugarman et al. (1995) and Miller et al. (1999) examined the base of the Navesink Formation at various localities in New Jersey. Using strontium isotope analyses, they concluded that the age of the base varies depending on the locality, becoming younger toward the south. They did not sample the basal part of the formation at Atlantic Highlands. However, our ammonite data suggest that the phosphatic bed near the base of the Navesink Formation at this site represents a condensed sequence, spanning the late Campanian to early Maastrichtian. Through a series of processes involving burial, phosphatization, and reworking, the older, late Campanian ammonites were intermixed with the remains of younger, early Maastrichtian ammonites, forming the phosphatic accumulations near the base of the Navesink Formation. The base of the lower phosphatic bed itself probably represents a hiatus. This conclusion is very similar to interpretations drawn from the distribution of calcareous nannoplankton indicating that the Campanian/Maastrichtian boundary occurs somewhere between the top of the Mount Laurel and the base of the Navesink formations (Sugarman et al., 1995: 34, fig. 16).

CORRELATION WITH WESTERN EUROPE: Figure 3 shows the present biostratigraphic divisions based on macrofossils across the Campanian—Maastrichtian boundary in Western Europe. Following the Second International Symposium on Cretaceous Stage

TABLE 1

Biostratigraphic Sequence of Previously Suggested Markers for Campanian-Maastrichtian Boundary in Western Europe (see Kennedy and Cobban, 1993)

(youngest)
extinction of *Quadrum trifidum* (nannofossil)
appearance of *Pachydiscus* (*P.*) *neubergicus* (ammonite)
appearance of *Hoploscaphites constrictus* (ammonite)
appearance of *Belemnella lanceolata lanceolata* (belemnite)
extinction of *Globotruncanita calcarata* (foraminifer)
appearance of *Globotruncana falsostuarti* (foraminifer)
(oldest)

Boundaries held in Brussels in 1995 (Rawson et al., 1996), preliminary agreement has been reached that the base of the Maastrichtian is defined by the first appearance of the ammonite *Pachydiscus* (*P.*) *neubergicus* (Hauer, 1858) (Odin, 1996). This and other previously suggested markers can be placed in sequence, as discussed by Kennedy and Cobban (1993), as in table 1.

The *hyatti* zone fauna of the Navesink Formation at Atlantic Highlands can be directly correlated with the highest European Campanian, the *Nostoceras pozaryskii* zone of Błaszkiewicz (1980), and the higher part of the *Belemnella langei* zone (fig. 3). This is based on the recognition that the types of *N.* (*N.*) *pozaryskii* are specimens of both *N.* (*N.*) *hyatti* and *N.* (*N.*) *helicinum*, while *Acanthoscaphites praequadrispinosus* Błaszkiewicz, 1980, which is restricted to the "*pozaryskii*" zone, is closely similar to *Jeletzkytes* cf. *J. nodosus*, described below. The *pozaryskii* zone should be renamed the *N.* (*N.*) *hyatti* zone in our view.

The occurrence of *Pachydiscus* (*P.*) *neubergicus* in the lower phosphatic bed at Atlantic Highlands can be correlated with the *Belemnella lanceolata* zone of the European lower Maastrichtian. This correlation is further supported by the close similarity between *Nostoceras* (*N.*) *mendryki*, which occurs in the upper phosphatic bed, and *N.* (*N.*) *schloenbachi* (Favre, 1869), as already pointed out by Cobban (1974a).

CORRELATION WITH THE GULF COAST: The *Nostoceras* (*N.*) *hyatti* zone can be widely recognized in the Gulf Coast. The Saratoga Chalk of Arkansas yielded 17 species (Kennedy and Cobban, 1993): *Gaudryceras* sp. (rare), *Pachydiscus* (*P.*) *arkansanus* (Stephenson, 1941) (rare), *Pseudokossmaticeras galicianum* (Favre, 1869) (rare), *Nostoceras* (*N.*) *approximans* (common), *N.* (*N.*) *helicinum* (common), *N.* (*N.*) *hyatti* (common), *N.* (*N.*) *pauper* (uncommon), *N.* (*N.*) *colubriformis* Stephenson, 1941 (rare), *N.* (*N.*) n. sp. (rare), *Cirroceras conradi* (uncommon), *Didymoceras draconis* (Stephenson, 1941) (rare), *Lewyites oronensis* (uncommon), *Solenoceras* cf. *S. texanum* (Shumard, 1861) (rare), *Baculites undatus* Stephenson, 1941 (rare), *B. ovatus* (abundant), *Hoploscaphites pumilus* (uncommon), and *Jeletzkytes nodosus* (rare) (referred to in the present paper as *Jeletzkytes* cf. *J. nodosus*).

In Tennessee, the *Nostoceras* (*N.*) *hyatti* zone is represented in the Coon Creek Tongue of the Ripley Formation at its type locality (Wade, 1926). Ammonites include *N.* (*N.*) *hyatti*, *N.* (*N.*) *approximans*, *Cirroceras conradi*, *Parasolenoceras* sp., *Solenoceras* sp., *Baculites claviformis*, and *Jeletzkytes nodosus* (referred to in the present paper as *Jeletzkytes* cf. *J. nodosus*).

In northeast Texas, *Nostoceras* (*N.*) *hyatti* zone ammonites occur at several localities in the Nacatoch Sand. United States Geological Survey (USGS) Mesozoic locality 17368, 4.1 km southwest of Corsicana, Navarro County, is low in the Nacatoch, with *N.* (*N.*) *hyatti*?, *N.* (*N.*) *colubriformis* (Stephenson, 1941), *Solenoceras multicostatum* Stephenson, 1941, and *S. texanum*. USGS Mesozoic locality 518, at the north edge of Corsicana, is higher, with *N.* (*N.*) *hyatti*, *N.* (*N.*) *helicinum*, *S. multicostatum*, and *Baculites undatus*. USGS Mesozoic locality 762, near Chatfield, Navarro County, is high in the Nacatoch, with *Pachydiscus* (*P.*) *arkansanus*, *N.* (*N.*) *helicinum*, *N.* (*N.*) *approximans*, *N.* (*N.*) *splendidus*, *Cirroceras conradi*, *S. multicostatum*, *S. texanum*, *B. undatus*, *Hoploscaphites pumilus*, and *Jeletzkytes* cf. *J. nodosus*.

The higher phosphatic bed in the Navesink Formation at Atlantic Highlands yields *N.* (*N.*) *mendryki*, which is also known from the Maastrichtian Prairie Bluff Chalk in Alabama. *Nostoceras* (*N.*) *alternatum*, which occurs as float at Big Brook, near Marlboro,

New Jersey, defines the second zone of the Maastrichtian in the Gulf Coast region (Cobban and Kennedy, 1995). This species is represented in the Coon Creek Tongue of the Ripley Formation in northeastern Mississippi and nine other localities in equivalent parts of the Ripley Formation in Alabama and Georgia, as well as in the Nacatoch Sand in southwestern Arkansas. Rare phosphatized fragments of this species also occur in the Prairie Bluff Chalk in Alabama.

Eubaculites labyrinthicus is present in the Prairie Bluff Chalk in Alabama. *Jeletzkytes criptonodosus* occurs in the Prairie Bluff Chalk in Alabama and in the Ripley Formation in Union County, Mississippi. *Discoscaphites gulosus* is known from the Severn Formation in Maryland, the Prairie Bluff Chalk in Alabama, and the Corsicana Formation in Texas.

CORRELATION WITH THE WESTERN INTERIOR: *Nostoceras* (*N.*) *hyatti* is known only from the *Baculites jenseni* zone near Walsenburg, Colorado. The *N.* (*N.*) *hyatti* zone is certainly equivalent to the *B. jenseni* zone, and may or may not encompass lower levels in the Western Interior as well. Of the younger elements at Atlantic Highlands, *Jeletzkytes* cf. *J. plenus* is closely similar to forms from the *Baculites eliasi* zone in Wyoming and Montana. *Jeletzkytes criptonodosus*, which is known from the Navesink Formation near Middletown, New Jersey, occurs in the *Baculites baculus* zone in the southern part of the Canadian Western Interior and in the *Baculites grandis* zone in the U.S. Western Interior. *Discoscaphites gulosus*, known from Sewell, New Jersey, occurs in the *Hoploscaphites nicolletii* and *Jeletzkytes nebrascensis* zones.

LOCALITIES OF COLLECTIONS

Most of the specimens described here were collected by members of the Monmouth Amateur Paleontologists Society from the celebrated Atlantic Highlands locality in northern Monmouth County, New Jersey, which was described by Minard (1969). This and other relevant localities are shown in figure 2 and described in the text.

CONVENTIONS

The following abbreviations indicate the repositories of specimens cited in the text:

American Museum of Natural History, New York (**AMNH**)
Academy of Natural Sciences, Philadelphia (**ANSP**)
The Natural History Museum, London (**BMNH**)
Geological Survey of Canada, Ottawa (**GSC**)
Monmouth Amateur Paleontologists Society, West Long Branch, New Jersey (**MAPS**). This collection is bequeathed to the American Museum of Natural History (AMNH), New York. Casts of certain specimens are reposited in the USNM and AMNH collections.
New Jersey State Museum, Trenton (**NJSM**)
U.S. National Museum of Natural History, Washington DC (**USNM**)

Suture terminology is that of Wedekind (1916), as reviewed by Kullmann and Wiedmann (1970), with E = external lobe, L = lateral lobe, U = umbilical lobe, and I = internal lobe. The term "rib index" as applied to heteromorphs is the number of ribs in a distance equal to the whorl height at the midpoint of the interval counted. All dimensions are given in millimeters: D = diameter, Wb = whorl breadth, Wh = whorl height, and U = umbilical diameter. Figures in parentheses are dimensions as a percentage of diameter. Specimens are photographed in the conventional position with the aperture on top except for complete or nearly complete specimens of scaphites.

SYSTEMATIC PALEONTOLOGY

ORDER AMMONOIDEA ZITTEL, 1884

SUBORDER LYTOCERATINA HYATT, 1889

SUPERFAMILY TETRAGONITACEAE HYATT, 1900

FAMILY TETRAGONITIDAE HYATT, 1900

Genus *Pseudophyllites* Kossmat, 1895

Type Species: *Ammonites indra* Forbes, 1846 (p. 105, pl. 11, fig. 7, by original designation).

Pseudophyllites indra (Forbes, 1846)

Figure 4C–K, R

Ammonites Indra Forbes, 1846: 105, pl. 11, fig. 7.

Ammonites Garuda Forbes, 1846: 102, pl. 7, fig. 1.
Pseudophyllites indra (Forbes, 1846), Kennedy and Klinger, 1977: 182, figs. 19a–f, 20–22 (with full synonymy).
Pseudophyllites indra (Forbes, 1846), Henderson and McNamara, 1985: 50, pl. 2, figs. 7, 8, pl. 3, figs. 4, 5, text-figs. 5a, d.
Pseudophyllites indra (Forbes), Stinnesbeck, 1986: 199, pl. 8, fig. 4.
Pseudophyllites indra (Forbes, 1846), Kennedy, 1986a: 19, pl. 1, figs. 1–5, text-figs. 4e, 5a, 6a–e (with additional synonymy).
Pseudophyllites cf. *indra* (Forbes, 1846), Kennedy and Summesberger, 1986: 187, pl. 1, figs. 1, 8, pl. 3, fig. 5, text-fig. 4 (with additional synonymy).
Pseudophyllites Kennedy, 1989: fig. 17b.
Pseudophyllites indra (Forbes), Cobban and Kennedy, 1991: E2, pl. 1, figs. 1–5.
Pseudophyllites indra (Forbes, 1846), Shigeta, 1992: 1158, figs. 1–4.
Pseudophyllites indra (Forbes, 1846), Ward and Kennedy, 1993: 22, figs. 17.8, 18.9, 18.10, 19.7, 19.9, 19.13, 21.1, 21.2, 22.1, 22.2, 27.6.
Pseudophyllites indra (Forbes, 1846), Hancock and Kennedy, 1993: 153, pl. 1, figs. 3, 4.
Pseudophyllites indra (Forbes, 1846), Kennedy and Hancock, 1993: 577, pl. 1, figs. 4, 7.
Pseudophyllites indra (Forbes, 1846), Cobban and Kennedy, 1995: 4, figs. 2.1–2.4, 2.10.
Pseudophyllites indra (Forbes, 1846), Kennedy et al., 1995: pl. 6, figs. 4, 5.
Pseudophyllites indra (Forbes, 1846), Kennedy and Christensen, 1997: 85, fig. 5D.

LECTOTYPE: The lectotype is BMNH C51068, the original of Forbes, 1846: pl. 11, figs. 7a, b, from the Valudavur Formation of Pondicherry, south India, designated by Kennedy and Klinger, 1977: 182.

DESCRIPTION: There are four fragments all belonging to the same individual (USNM 445420) (fig. 4C–K, R). This material includes a nucleus 9 mm in diameter (fig. 4H–K) enclosed by a whorl fragment with a whorl height of 13.2 mm (fig. 4E–G), a mold of a septal lobe (fig. 4C, D), and a septate fragment (fig. 4R). The coiling is involute with a small, deep umbilicus. The whorl section is equidimensional and reniform; the umbilical shoulder is inclined outward and the flanks and venter are broadly and evenly rounded. Internal molds are smooth. The suture is imperfectly exposed; it is deeply and intricately subdivided as is typical for the genus. The external saddle is typical for the species and there is a massive septal lobe.

DISCUSSION: Differences between *Pseudophyllites indra* and other species of the genus are discussed by Kennedy and Klinger (1977) and Kennedy (1986a). The whorl section, septal lobe, and form of the external saddle all indicate that these fragments belong to the type species, *P. indra*.

OCCURRENCE: The Navesink specimen is from the lower phosphatic layer at Atlantic Highlands, New Jersey. Elsewhere in the United States, *P. indra* occurs as a rarity in the upper Campanian Nacatoch Sand in northeast Texas, in the lower Maastrichtian *Nostoceras* (*N.*) *alternatum* zone in the Nacatoch Sand in southwest Arkansas, and in the Maastrichtian Prairie Bluff Chalk in Alabama. Outside the United States, the species may appear in the upper Santonian, but is mostly known from the lower Campanian to upper Maastrichtian. There are records from south India, Zululand and Pondoland (South Africa), Madagascar, western Australia, Japan, Sakhalin, Alaska, British Columbia, California, Brazil, Chile, northern Ireland, southern Sweden, Poland, Austria, and southwest France.

SUPERFAMILY DESMOCERATACEAE ZITTEL, 1895

FAMILY DESMOCERATIDAE ZITTEL, 1895

SUBFAMILY PUZOSIINAE SPATH, 1922

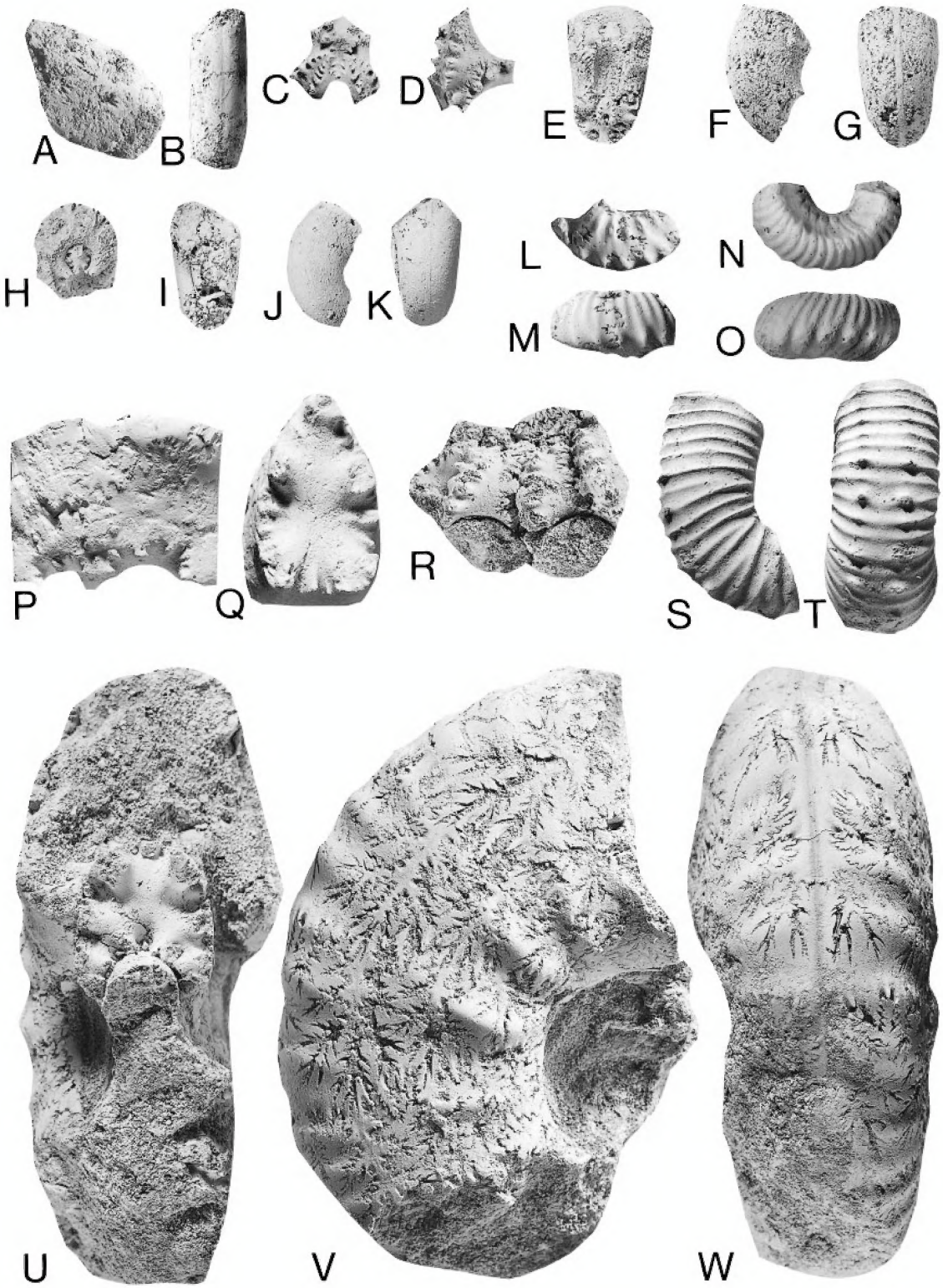
Genus *Kitchinites* Spath, 1922

Type Species: *Holcodiscus pondicherryanus* Kossmat, 1897 (p. 40[147], pl. 6 [17], fig. 6, by original designation).

Kitchinites sp.

Figure 4A, B

DESCRIPTION: MAPS A2010a1 is a planulate fragment 28 mm long with a maximum preserved whorl height of 16 mm and a ratio of whorl breadth to whorl height of 0.58. Coiling is moderately involute, with a very shallow umbilicus. The umbilical wall is flattened and the umbilical shoulder is narrowly rounded. The inner flanks are flattened and subparallel and the outer flanks are convergent. The ventrolateral shoulders are narrowly rounded and the venter is flattened to fee-


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W

bly concave. The surface of the mold is smooth. The suture is poorly preserved, but appears to have been moderately incised and of puzosiine type.

DISCUSSION: The coiling and suture suggest Puzosiinae, while the lack of ornament finds a match in certain *Kitchinites*, such as juvenile *Kitchinites spathi* Henderson and McNamara, 1985, p. 57, pl. 4, figs. 5, 6, 9, 10, 14, 15, text-fig. 6b, c, which leads us to refer the fragment to *Kitchinites* sp.

OCCURRENCE: Lower phosphatic layer, basal Navesink Formation, Atlantic Highlands, New Jersey.

FAMILY PACHYDISCIDAE SPATH, 1922

Genus and Subgenus *Pachydiscus* Zittel, 1884

TYPE SPECIES: *Ammonites neubergicus* Hauer, 1858 (p. 12, pl. 2, figs. 1–3, pl. 3, figs. 1, 2) by the subsequent designation of de Grossouvre (1894: 177).

Pachydiscus (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858)

Figure 4U–W

Ammonites neubergicus Hauer, 1858: 12, pl. 2, figs. 1–3, non pl. 3, figs. 1, 2.

Pachydiscus (*Pachydiscus*) *neubergicus* (von Hauer, 1858), Kennedy and Summesberger, 1986: 189, pl. 2, figs. 1, 2, pl. 3, figs. 1–3, pl. 4, figs. 1–5, pl. 5, figs. 1, 4, 5, pl. 6, figs. 1, 2, 5, pl. 15, figs. 7, 8, text-figs. 5a, b (with full synonymy).

Pachydiscus (*Pachydiscus*) *neubergicus* (Hauer, 1858), Kennedy, 1986b: 34, pl. 4, fig. 3.

?*Pachydiscus* (*Pachydiscus*) cf. *neubergicus* (Hauer, 1858), Vasicek, 1988: 76, pl. 1, fig. 3.

Pachydiscus (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858), Kennedy and Henderson, 1992: 420, pl. 10, figs. 6–8, pl. 11, text-fig. 6A (with additional synonymy).

Pachydiscus (*Pachydiscus*) *neubergicus* (Hauer, 1858), Hancock and Kennedy, 1993: 158, pl. 3, figs. 6, 7, pl. 9, figs. 5–8, pl. 12, figs. 7–9, pl. 13, figs. 5–7.

Pachydiscus (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858), Ward and Kennedy, 1993: 30, figs. 25.9–25.12, 25.14, 25.16–25.18, 27.3–27.5, 27.7, 28.1–28.3, 30.4, 30.6.

Pachydiscus (*Pachydiscus*) *neubergicus* (Hauer, 1855), Kennedy et al., 1995: pl. 6, figs. 16, 17.

LECTOTYPE: The lectotype is No. 1858.01.6 in the collections of the Geologische Bundesanstalt, Vienna, the original of Hauer, 1858 (pl. 2, figs. 1–3), designated by de Grossouvre, 1894 (p. 209; see Kennedy and Summesberger, 1986: pl. 3, figs. 1–3). It is from the lower Maastrichtian of Neuberg, Steiermark, Austria.

DESCRIPTION: MAPS A2045a2 (not illustrated, plaster cast USNM 445245) has a whorl height of 19.5 mm. The ratio of whorl breadth to whorl height is 0.9. The umbilical shoulder is narrowly rounded. The inner flanks are broadly rounded, the outer flanks are convergent, and the venter is broadly rounded. Three distant umbilical bullae give rise to narrow, prorsiradiate ribs that weaken on the middle of the flanks but strengthen on the outer flanks. Several intercalated ribs are present between the primaries; they arise on the middle to outer flanks, so that there are 14 ventral ribs corresponding to the three bullae; these ribs strengthen over the venter, which they cross in a broad convexity.

MAPS A2045a1 (fig. 4U–W, plaster cast USNM 445424) is a much larger fragment, wholly septate to a whorl height of 50 mm. The whorl section is compressed with a ratio

←

Fig. 4. **A, B.** *Kitchinites* sp., MAPS A2010a1. **C–K, R.** *Pseudophyllites indra* (Forbes, 1846), USNM 445420. **L–O.** *Nostoceras* (*Nostoceras*) *alternatum* (Tuomey, 1854). **L, M.** MAPS A2041a1, float, Big Brook, near Marlboro, Monmouth County. **N, O.** NJSM 17737, said to be from Atlantic Highlands but probably from Big Brook, Monmouth County. **P, Q.** *Eubaculites* cf. *E. labyrinthicus* (Morton, 1834), plaster cast USNM 445379, Crosswicks Creek, near Allentown, Monmouth County. **S, T.** *Nostoceras* (*Nostoceras*) *approximans* (Conrad, 1855), USNM 445248. **U–W.** *Pachydiscus* (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858), MAPS A2045a1, plaster cast USNM 445424. All specimens are from the lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey, unless otherwise stated. A–G, L–W are ×1; H–K are ×2.

of whorl breadth to whorl height of 0.8, with the greatest breadth at the umbilical shoulder. The umbilicus is moderately deep, the umbilical wall is flattened and inclined outward, and the umbilical shoulder is rounded. The inner flanks are broadly rounded, the outer flanks are flattened and convergent, and the ventrolateral shoulders are broadly rounded. The venter is quite broad and flattened. Six umbilical bullae are present in the 150° sector preserved; they are strong, feebly concave, and give rise to prorsiradiate ribs that weaken across the middle of the flanks. Pairs of intercalated ribs arise on the outer flanks, and all ribs strengthen markedly across the venter. The suture is imperfectly preserved, but is intricately subdivided and typical for the genus.

DISCUSSION: Cobban (1974a: 18, pl. 11, figs. 5–8, text-fig. 15) recorded juvenile *Pachydiscus* sp. from the Navesink Formation at Atlantic Highlands, which Błaszkiewicz (in Cobban, 1974a: 18) considered to be most similar to *P.* (*P.*) *neubergicus*. The larger fragment illustrated here confirms this view and demonstrates beyond doubt the presence of this important Maastrichtian marker species in the eastern United States. Kennedy and Summesberger (1986) provided a full description and synonymy of this species, and illustrated the lectotype and topotype material. Differences between *P.* (*P.*) *neubergicus neubergicus* and subspecies *P.* (*P.*) *neubergicus dissitus* Henderson and McNamara, 1985 (p. 72, pl. 7, figs. 7, 9, pl. 10, figs. 3–6, text-figs. 11, 12c, 13c) are fully described by these authors.

OCCURRENCE: The Navesink specimens are from the lower phosphatic layer at Atlantic Highlands, New Jersey. The species is typically lower Maastrichtian in Europe, but ranges up into the lower part of the upper Maastrichtian *Belemnitella junior* belemnite zone. It is known from Denmark, north Germany, Austria, Czechoslovakia, Russia, southwestern France, northeastern Spain, Nigeria, southern India, Zululand (South Africa), and Madagascar, with subspecies *dissitus* in the upper Maastrichtian of western Australia.

SUBORDER ANCYLOCERATINA WIEDMANN, 1966

SUPERFAMILY TURRILITACEAE GILL, 1871

FAMILY NOSTOCERATIDAE Hyatt, 1894

Genus and Subgenus *Nostoceras* Hyatt, 1894

TYPE SPECIES: *Nostoceras stantoni* Hyatt, 1894, p. 569; by original designation = *Ancyloceras*? *approximans* Conrad, 1855, p. 266.

Nostoceras (*Nostoceras*) *approximans* (Conrad, 1855)

Figures 4S, T, 5A–E, K–O

Ancyloceras approximans Conrad, 1855: 266.
Ancyloceras approximans Conrad, Conrad, 1860: pl. 47, fig. 4.
Nostoceras stantoni Hyatt, 1894: 570.
Nostoceras stantoni aberrans Hyatt, 1894: 572.
Nostoceras stantoni retrorsum Hyatt, 1894: 579.
Nostoceras stantoni prematurum Hyatt, 1894: 572.
Nostoceras stantoni Hyatt, Roman, 1938: 445.
Nostoceras stantoni Hyatt, Stephenson, 1941: 407, pl. 80, figs. 1–5.
Nostoceras stantoni aberrans Hyatt, Stephenson, 1941: 409, pl. 80, figs. 9, 10.
Nostoceras stantoni retrorsum Hyatt, 1894, Stephenson, 1941: 408.
Nostoceras stantoni prematurum Hyatt, Stephenson, 1941: 409, pl. 80, figs. 6–8. non *Nostoceras* spec. aff. *stantoni aberrans* Hyatt, Bürgl, 1955: 43, pl. 6, fig. 12.
non *Nostoceras* spec. aff. *stantoni aberrans*, Hyatt, Bürgl, 1957: pl. 17, fig. 3.
non *Nostoceras stantoni serratum* Collignon, 1971: 12, pl. 644, fig. 2383.
Nostoceras cf. *N. stantoni* Hyatt, Cobban, 1974a: 12, pl. 9, figs. 23–31, text-fig. 9.
?*Nostoceras* sp. cf. *N. stantoni* Hyatt, Matsumoto, 1977: 323, pl. 61, fig. 3.
Nostoceras (*Nostoceras*) *approximans* (Conrad, 1855), Kennedy et al., 1995: pl. 6, figs. 9–12.

HOLOTYPE: The holotype is the original of Conrad (1855: 266), by monotypy. It is ANSP 12861, and was said to be from White River, Arkansas.

DISCUSSION: Cobban (1974a) had only helices of this species for his original account of the Navesink fauna. Subsequent collecting has produced adult body chambers that correspond to the holotype of *Nostoceras* (*N.*) *approximans* and to *N.* (*N.*) *stantoni* Hyatt, 1894 (Stephenson, 1941: 407, pl. 80, figs. 1–

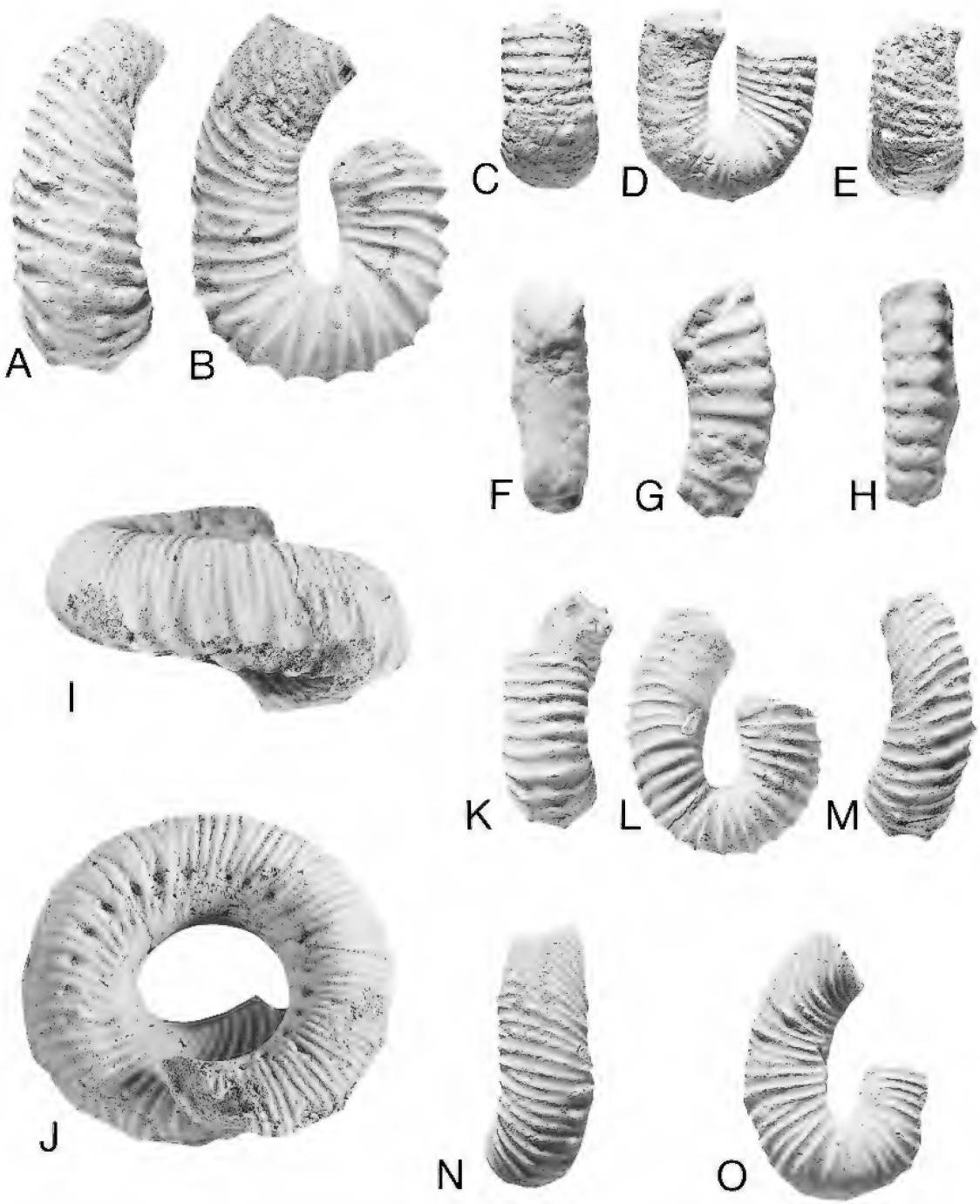


Fig. 5. **A–E, K–O.** *Nostoceras* (*Nostoceras*) *approximans* (Conrad, 1855). **A, B.** MAPS A2027a2, macroconch; **C–E.** holotype, ANSP 12861, microconch, White River, Arkansas; **K–M.** MAPS 2027a1, microconch; **N, O.** USNM 445246, pathological microconch. **F–H.** *Exiteloceras rude*, n. sp., holotype, USNM 433778, Big Brook, near Marlboro, Monmouth County. **I, J.** *Didymoceras* cf. *D. draconis* (Stephenson, 1941), MAPS A2040b1. All specimens are from the lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey, unless otherwise stated. All figures are ×1.

5), which is treated as a junior synonym. Figured microconchs include the holotype, ANSP 12861 (fig. 5C–E) and MAPS A2027a1 (fig. 5K–M). One specimen, USNM 445246, has suffered an injury in life, and, as a result, one of its rows of tubercles is greatly reduced (fig. 5N, O). An adult macroconch body chamber (MAPS A2027a2) is illustrated as figure 5A, B.

OCCURRENCE: Upper Campanian; lower phosphatic layer, basal part of Navesink Formation, Atlantic Highlands, New Jersey; Nacatoch Sand of northeast Texas; Saratoga Chalk of Arkansas; *Baculites jenseni* zone in the Pierre Shale of Colorado. Records from Colombia and Madagascar belong to other species; that from Japan is doubtful.

Nostoceras (*Nostoceras*) *hyatti* Stephenson, 1941

Figures 6, 7G–I

Nostoceras hyatti Stephenson, 1941: 410, pl. 81, figs. 9–12.
Nostoceras hyatti Stephenson, Cobban, 1974a: 10, pl. 5, figs. 1–21, pl. 6, figs. 1–12, pl. 7, figs. 1–10, pl. 8, figs. 1–30, text-fig. 8 (with full synonymy).
Nostoceras (*Nostoceras*) *pozaryskii* Błaszkiewicz, 1980: 26 (part), pl. 10, figs. 8, 9, 12 only.
Nostoceras (*Nostoceras*) *hyatti* Stephenson, 1941, Kennedy, 1986a: 90, pl. 20, figs. 7–9.
Nostoceras (*Nostoceras*) *hyatti* Stephenson, 1941, Kennedy and Cobban, 1993: 417, figs. 9.2, 11.1–11.27.
Nostoceras (*Nostoceras*) *hyatti* Stephenson, 1941, Ward and Kennedy, 1993: 14, fig. 15.1, 15.2.
Nostoceras (*Nostoceras*) *hyatti* Stephenson, 1941, Hancock and Kennedy, 1993: 162, pl. 9, figs. 1–4, pl. 14, figs. 2–4, pl. 16, figs. 2, 3, pl. 17, figs. 10, 11, pl. 18, figs. 2–4, 6, 7, pl. 19, figs. 1–4, 8–10.
Nostoceras (*Nostoceras*) *hyatti* Stephenson, 1941, Kennedy et al., 1995: pl. 6, figs. 7, 8, pl. 7, figs. 9, 10.

TYPES: The holotype is USNM 77258, the original of Stephenson, 1941: pl. 81, fig. 9, from the Nacatoch Sand on Postoak Creek at the north edge of Corsicana, Navarro County, Texas. There are four paratypes.

DISCUSSION: We have examined more than 100 specimens in addition to those described by Cobban (1974a). These show marked size dimorphism as demonstrated by figure 6A–C, a microconch, and figure 6D–F and figure 7G–I, two macroconchs, the latter pathological. Kennedy was also able to examine the type specimens and topotypes of *Nostoceras pozaryskii* Błaszkiewicz, 1980, and is convinced that this species is in part based on specimens of *N.* (*N.*) *hyatti*, notably the original of Błaszkiewicz, pl. 10, figs. 8, 9, 12. The holotype (Błaszkiewicz, 1980: pl. 10, figs. 1–5) is a specimen of *N.* (*N.*) *helicinum*, as are the originals of his pl. 10, figs. 6, 7, 10, 11, 13–15.

OCCURRENCE: Upper Campanian; lower phosphatic layer, basal part of Navesink Formation, Atlantic Highlands, New Jersey; Nacatoch Sand of northeast Texas; Coon Creek Tongue of Ripley Formation in Tennessee; Saratoga Chalk in Arkansas; Angola?; Israel; Tercis, Landes, France; Maurens, Aquitaine, France; and the Vistula Valley, Poland.

Nostoceras (*Nostoceras*) *alternatum* (Tuomey, 1854)

Figure 4L–O

Turrulites alternatns (sic) Tuomey, 1854: 168.
Turrilites spinifera Conrad, 1860: 284.
Turrilites spinifera Conrad, Gabb, 1861b: 92.
Turrilites alternatus Tuomey, Gabb, 1861b: 91.
Nostoceras alternatum (Tuomey), Cobban, 1974b: 86, figs. 1w–rr, 5.
Nostoceras (*Nostoceras*) *alternatum* (Tuomey, 1854), Cobban and Kennedy, 1991: E3, pl. 2, figs. 5–27.
Nostoceras (*Nostoceras*) *alternatum* (Tuomey, 1854), Cobban and Kennedy, 1995: 14, figs 9.10, 9.11.

TYPES: The types were from Noxubee County, Mississippi, but are lost.

DESCRIPTION: MAPS A2041a1 (fig. 4L, M) is a septate fragment 21 mm long with a maximum preserved whorl height of 11.5 mm. It has a concave upper whorl face and an outer whorl face that is broadly rounded above and flattened below. The juncture of the outer and lower whorl faces is narrowly rounded; the lower whorl face is flattened. Twelve narrow ribs are straight and transverse to slightly concave and prorsiradiate on the outer whorl face. Six strong, transversely elongate tubercles are present at the juncture of the outer and lower whorl faces. Each tubercle is linked to a single rib or a pair of ribs and gives rise to one or two distant, narrow, feebly convex ribs on the lower whorl

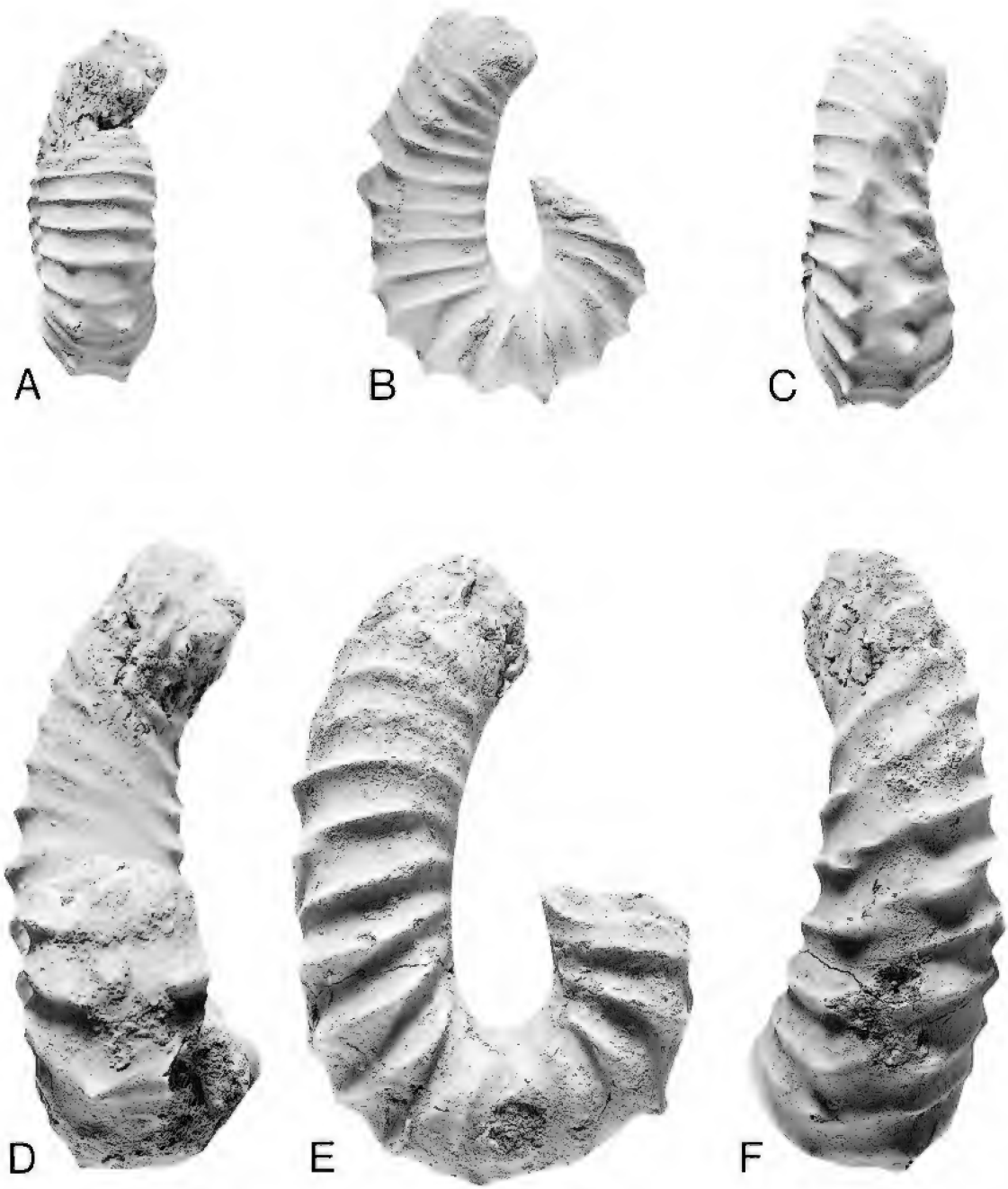


Fig. 6. *Nostoceras* (*Nostoceras*) *hyatti* Stephenson, 1941. **A–C.** MAPS A2004a1, microconch; **D–F.** MAPS A2004a2, macroconch. All specimens are from the lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey. All figures are ×1.

face. These ribs either link singly or zig-zag in pairs to transversely elongated tubercles at the margin of the umbilicus. The suture is moderately incised with broad, bifid saddles.

NJSM 17737 (fig. 4N, O) is a water-worn fragment of a body chamber (no sutures are visible) 23.5 mm long with a maximum preserved height of 11.0 mm. There are seven

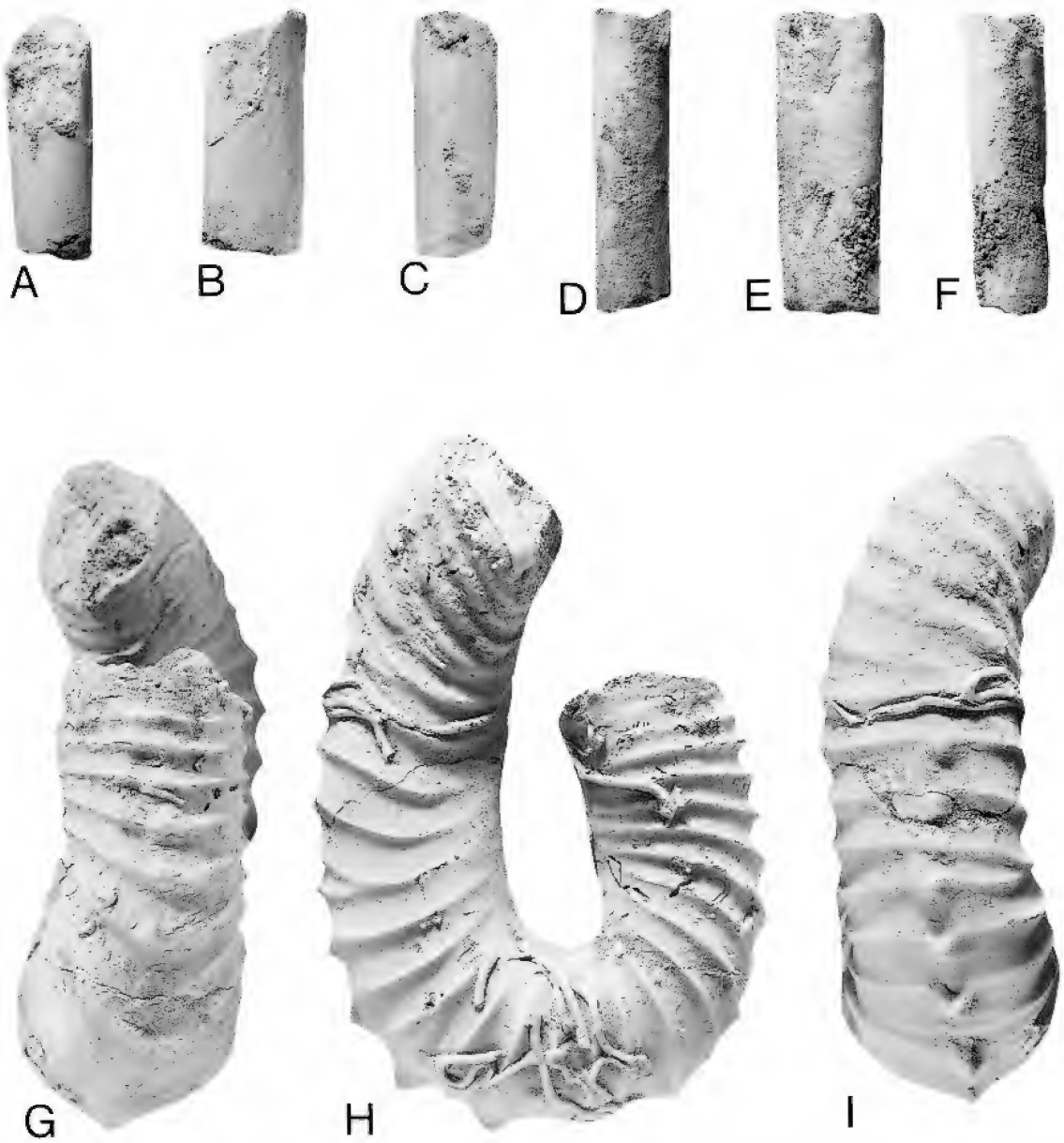


Fig. 7. **A–F.** *Baculites* sp. **A–C.** NJSM 13439; **D–F.** NJSM 12931. Both specimens are from the Navesink Formation, Inversand Pit, Sewell, Gloucester County, New Jersey. **G–I.** *Nostoceras* (*Nostoceras*) *hyatti* Stephenson, 1941, MAPS A2004a3, pathological macroconch with only one row of ventral tubercles, lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey. All figures are ×1.

tubercles at the juncture of the outer and lower whorl faces.

DISCUSSION: The distribution of tubercles, with one row at the juncture of the outer and lower whorl faces, and the other close to the umbilicus on the base of the whorl, immediately distinguishes this species from all other representatives of the genus.

OCCURRENCE: Lower Maastrichtian; float, presumably from basal 3 m of Navesink Formation, Big Brook, near Marlboro, New Jersey; Coon Creek Tongue of Ripley Forma-

tion in Mississippi, and correlatives in Alabama and Georgia; and Nacatoch Sand in Arkansas.

Nostoceras (*Nostoceras*) *pauper* (Whitfield, 1892)

Figure 8A–H

Turrilites pauper Whitfield, 1892: 268, pl. 45, figs. 1–5.

Turrilites pauper Whitfield, Weller, 1907: 834, pl. 108, figs. 1–4.

Turrilites pauper Whitfield, Grabau and Shimer, 1910: 211, figs. 1484, 1485.

Nostoceras pauper (Whitfield), Cobban, 1974a: 12, pl. 9, figs. 1–22, text fig. 10.

Nostoceras (*Nostoceras*) *pauper* (Whitfield, 1892), Kennedy and Cobban, 1993: 420, fig. 7.5–7.7, 7.16–7.18, 7.24.

HOLOTYPE: The holotype, by monotypy, is NJSM 7659 from the Navesink Formation, New Jersey, the original of Whitfield, 1892: pl. 45, figs. 1–5.

DISCUSSION: Several additional specimens supplement those already described by Cobban (1947a). New specimens include both the spiral portions of the shell (fig. 8A–F) and the uncoiled body chamber (fig. 8G, H). They are all characterized by coarse ribs and two rows of tubercles, one at mid-flank and the other at the base of the outer whorl face. Differences between *Nostoceras* (*N.*) *pauper* and other species of the genus are discussed by Kennedy and Cobban (1993).

OCCURRENCE: Upper Campanian; lower phosphatic layer of Navesink Formation, Atlantic Highlands; float, presumably from basal Navesink Formation, Ramanessin Brook, Holmdel: and Big Brook, Marlboro, Monmouth County, New Jersey. Outside New Jersey, this species is known from the basal Saratoga Chalk, southwestern Arkansas.

Genus *Didymoceras* Hyatt, 1894

TYPE SPECIES: *Ancyloceras*? *Nebrascensis* Meek and Hayden, 1856 (p. 71); by original designation by Hyatt (1894: 574).

Didymoceras cf. *D. draconis* (Stephenson, 1941)

Figure 5I, J

compare:

Nostoceras? *draconis* Stephenson, 1941: 413, pl. 82, figs. 5–9.

DESCRIPTION: MAPS 2040b1 comprises just over one whorl of a helix with a maximum diameter of 57.4 mm; the maximum whorl height is 20.3 mm. The helix appears to have been low so that the whorls were in contact; the upper whorl surface is feebly concave to accommodate the base of the preceding whorl. The adapical half of the fragment is phragmocone, the remainder, body chamber. Narrow delicate ribs are markedly rursiradiate on the upper whorl face, but strengthen and cross the juncture of the upper and outer whorl faces in a feeble concavity, where they may bifurcate. The ribs are even, slightly prorsiradiate, and weakly concave on the outer whorl face; there are occasional intercalated ribs, yielding a total of approximately 85 ribs per whorl. The ribs join in pairs at relatively coarse, transversely elongated, flat-topped tubercles at the juncture of the outer and lower whorl faces, or intercalate between the tubercles. There are 27–30 tubercles per whorl. Single coarse ribs link to much smaller, sharper tubercles on the outer part of the lower whorl face, with single nontuberculate ribs between them. The ribs are strong and feebly convex across the remainder of the lower whorl face.

DISCUSSION: The position of the tubercle rows, one at the juncture of the outer and lower whorl faces and the other on the outer part of the lower whorl face, combined with fine, dense ribbing and large size, distinguish this specimen from all others in the Navesink fauna. This specimen most closely resembles *Didymoceras draconis* (Stephenson, 1941) (p. 413, pl. 82, figs. 5–9).

OCCURRENCE: Lower phosphatic layer, basal Navesink Formation, Atlantic Highlands, New Jersey.

Genus *Exiteloceras* Hyatt, 1894

TYPE SPECIES: *Ancyloceras jenneyi* Whitfield, 1877 (p. 42, by the subsequent designation of Diener, 1925, p. 88).

Exiteloceras rude, new species

Figure 5F–H

HOLOTYPE: USNM 433778, Navesink Formation, Big Brook, near Marlboro, Monmouth County, New Jersey.

ETYMOLOGY: Latin, *rudis*, rough.

DIAGNOSIS: An exceptionally coarse-ribbed species of *Exiteloceras*, with a rib index of 4.

DESCRIPTION: The holotype is a broadly, evenly curved septate fragment 37.5 mm long with a stout, oval whorl section 15.7 mm high and 13.1 mm wide; the greatest width is below mid-flank. The dorsum is broadly rounded and the flanks are very broadly rounded and converge to a slightly flattened, narrow venter. The ornament consists of strong, rounded, slightly rursiradiate, straight ribs with a rib index of 4. The ribs are weak on the dorsum, and strong on the flanks and venter. Each rib supports a strong, rounded tubercle at the margin of the venter. The suture is too poorly preserved for description.

DISCUSSION: This specimen is most unusual in its coarse ribbing and in its stratigraphic position. The rib index of 4 contrasts with 5 or more for comparable-sized specimens of *Exiteloceras jenneyi* (Whitfield, 1877), an older species. *Lewyites oronensis* (Lewy, 1969) (p. 127, pl. 3, figs. 10, 11), a loosely coiled planispiral heteromorph that has been found in the basal Navesink at Atlantic Highlands, New Jersey, is much more densely ribbed and has tubercles on every other rib.

OCCURRENCE: This specimen was found as float in the bed of Big Brook near Marlboro, Monmouth County, New Jersey, but is presumed to be derived from the Navesink Formation.

FAMILY BACULITIDAE GILL, 1871
[= EUBACULITINAE BRUNNSCHWEILER, 1966, p. 24]

Genus *Baculites* Lamarck, 1799
[= *Homaloceratites* Hupsch, 1768, p. 110 (non binominal); *Euhomaloceras* Spath, 1926, p. 80]

TYPE SPECIES: *Baculites vertebralis* Lamarck, 1801 (p. 103) by subsequent designation by Meek, 1876: 391.

Baculites sp.
Figure 7A–F

DESCRIPTION: NJSM 12931 (fig. 7D–F) is 44 mm long with an oval whorl section 16.0 mm high and 12.5 mm wide at its larger end. The taper angle of the shell is 3°. The only ornament is very weak, closely spaced ventral ribbing. The simple suture is poorly preserved. NJSM 13439 (fig. 7A–C) is a body chamber fragment 37 mm long with an oval whorl section 17.6 mm high and 13.1 mm wide in the middle of the specimen. Lirae are concave on the dorsal third of the flanks and project strongly forward on the ventral two-thirds of the flanks. The lirae strengthen into ribs and cross the venter with a narrow convexity.

NJSM GP 14257 (not illustrated) is a fragment 29 mm long, with an oval whorl section, 13.5 mm high and 9.3 mm wide at its larger end. The venter is very narrow and slightly pinched. The taper angle of the shell is 3°. Ornament is lacking, except for weak ventral ribs that have a rib index of 3. The incompletely preserved suture is simple, as for the genus.

DISCUSSION: In their small size, oval whorl section, narrow venter, and smooth flanks, these specimens resemble material from the Maastrichtian Prairie Bluff Chalk of Mississippi described as species A and C by Cobban and Kennedy (1995).

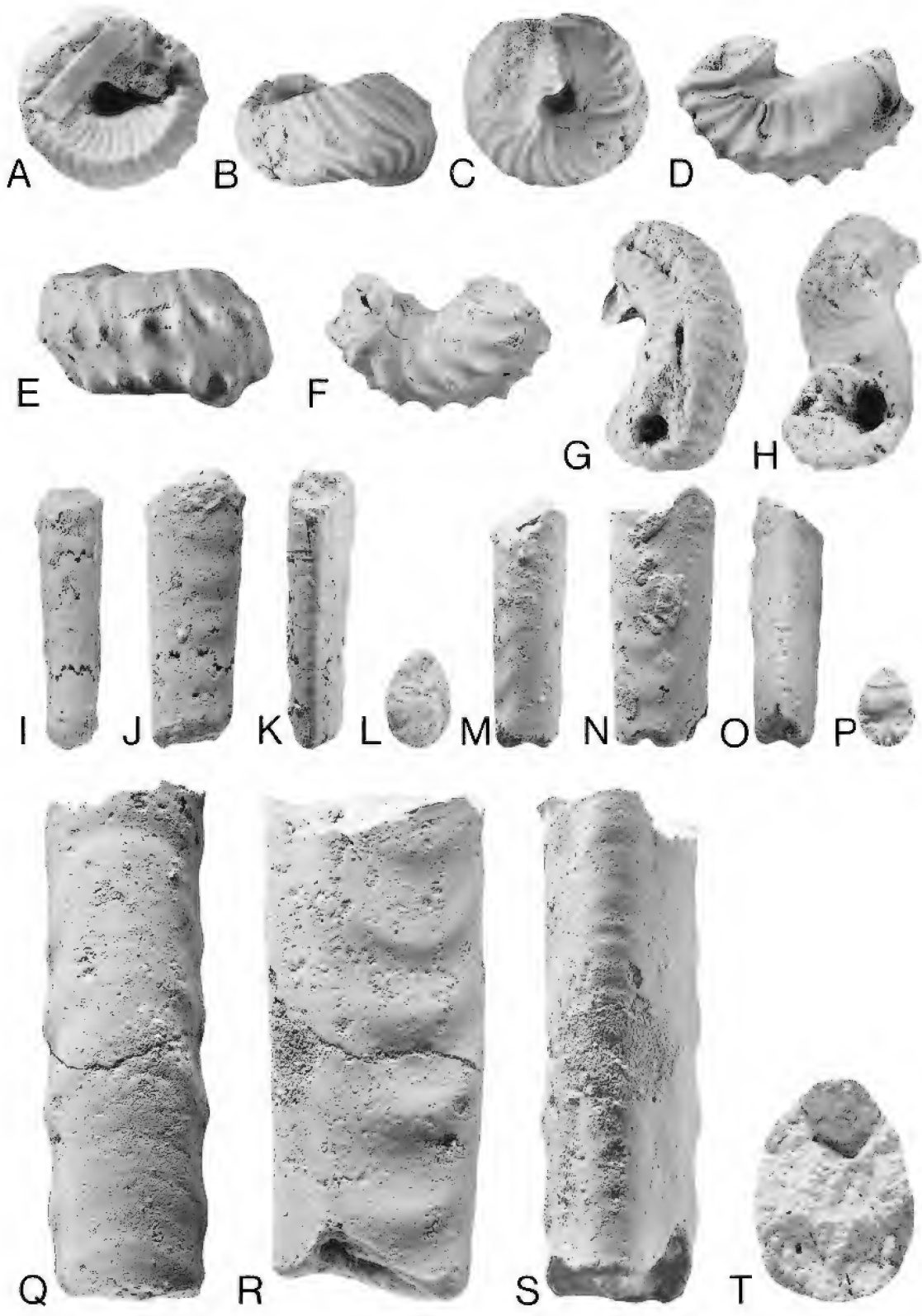
OCCURRENCE: Navesink Formation, Inversand Pit and along the bank of Chestnut Branch Creek, Sewell, Gloucester County, New Jersey (for details of this locality, see Richards, 1956: 79; Gallagher, 1984: 26; 1992; 1993: 142).

Genus *Eubaculites* Spath, 1926

TYPE SPECIES: *Baculites vagina* var. *Ootacodensis* Stoliczka, 1866 (p. 199, pl. 90, figs. 14, ?15), by original designation, from

→

Fig. 8. **A–H.** *Nostoceras* (*Nostoceras*) *pauper* (Whitfield, 1892). **A–C.** MAPS A2009b1, lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey. **D–F.** MAPS A2009b2, lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey. **G, H.** MAPS A2009c3, float, basal Navesink Formation, Ramanessin Brook, Holmdel, Monmouth County, New Jersey. **I–T.** *Eubaculites* sp.?, basal Navesink Formation, Crosswicks Creek, near Allentown, Monmouth County, New Jersey. **I–L.** MAPS A2057a1; **M–P.** MAPS A2057a2; **Q–T.** MAPS A2057a3. All figures are ×1.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T

the Maastrichtian of Ootacod, south India, = *Baculites labyrinthicus* Morton, 1834, p. 44, pl. 13, fig. 10.

Eubaculites cf. E. *labyrinthicus* (Morton, 1834)

Figure 4P, Q

compare:

Baculites labyrinthicus Morton, 1834: 44, pl. 13, fig. 10.

Baculites labyrinthicus Morton, Gabb, 1861a: 394, pl. 3, fig. 1.

Baculites labyrinthicus Morton, Gabb, 1861b: 77.

DESCRIPTION: USNM 445379 (fig. 4P, Q) is a plaster cast of a septate fragment 38.5 mm long, with a whorl height of 32.0 mm and a whorl breadth of 18.9 mm (ratio of whorl breadth to whorl height is 0.59). The dorsum is broad and flat with a narrowly rounded dorsolateral margin. The dorsal flanks are flattened and divergent; the mid-flank region, which is the point of greatest whorl breadth, is broadly rounded; the outer flanks are flattened and converge to a narrowly rounded venter. Traces of a transverse rib are preserved on the dorsal half of the flanks at the larger end of the specimen. The sutures are intricately subdivided.

DISCUSSION: The fastigiate rather than tabulate venter suggests that this is a specimen of *Eubaculites* nearest to *E. labyrinthicus* (Morton, 1834) (p. 44, pl. 13, fig. 10), originally described from the Prairie Bluff Chalk of Alabama. *Eubaculites carinatus* (Morton, 1834) (p. 44, pl. 13, fig. 1), the prior name of the widely recorded *E. lyelli* (d'Orbigny, 1847) (see Kennedy, 1987: 195, pl. 27, figs. 5–8, pl. 32, figs. 13, 14, with synonymy) is easily distinguished by its crescentic flank ribs and tabulate venter. *Eubaculites simplex* (Kossmat, 1895) (p. 156, pl. 19[5], figs. 13a, b, non pl. 19[5], figs. 14a, b) has a tabulate venter and is smooth. *Eubaculites vagina* (Forbes, 1846) (see figures in Klinger, 1976) has a tabulate venter and bituberculate flanks.

OCCURRENCE: This specimen was collected from the basal part of the Navesink Formation in a tributary on the west side of Crosswicks Creek south of Allentown, Monmouth County, New Jersey. The specimen is associated with a large collection of *Baculites ovatus*.

Eubaculites sp.?

Figure 8I–T

DESCRIPTION: MAPS A2057a1, 2 (fig. 8I–P) are two septate internal molds 41.0 and 43.5 mm long with taper angles of 4 and 6° and maximum whorl heights of 16.0 and 17.0 mm, respectively. The whorl section is oval with a narrow venter. The flanks are broadly rounded and the dorsum is well rounded. The flanks are ornamented by low, broad crescentic ribs, with a rib index of 3. No ribs are present on the venter. MAPS A2057a3 (fig. 8Q–T) is a very large septate fragment 79 mm long. It has a maximum whorl height and breadth of 35.7 mm and 25.7 mm, respectively. Like the smaller specimens, it has an oval whorl section with a broad dorsum and narrow venter. There are five broad crescentic ribs on the flanks, with a rib index of 3. The suture in all three specimens is fairly simple.

DISCUSSION: These specimens resemble *Eubaculites carinatus* (Morton, 1834) in their oval whorl section with narrow venter, flank ornament, and suture. They differ, however, in lacking a clearly defined tabulate venter. In addition, the large specimen is unusually large for this species.

OCCURRENCE: Basal part of the Navesink Formation in a tributary on the west side of Crosswicks Creek, south of Allentown, Monmouth County, New Jersey. The specimens are associated with a large collection of *Baculites ovatus* Say, 1820.

SUPERFAMILY SCAPHITACEAE GILL, 1871

FAMILY SCAPHITIDAE GILL, 1871

SUBFAMILY SCAPHITINAE GILL, 1871

Genus *Hoploscaphites* Nowak, 1911

TYPE SPECIES: *Ammonites constrictus* J. Sowerby, 1817, p. 189, pl. A, fig. 1, by original designation.

Hoploscaphites pumilus (Stephenson, 1941)

Figure 9A–F

Scaphites pumilus Stephenson, 1941: 426, pl. 90, figs. 10–12.

Discoscaphites erucoides Stephenson, 1941: 429, pl. 91, figs 2–4.

Hoploscaphites pumilus Stephenson, Cobban, 1974a: 16, pl. 11, figs. 9–12, text-fig. 13.

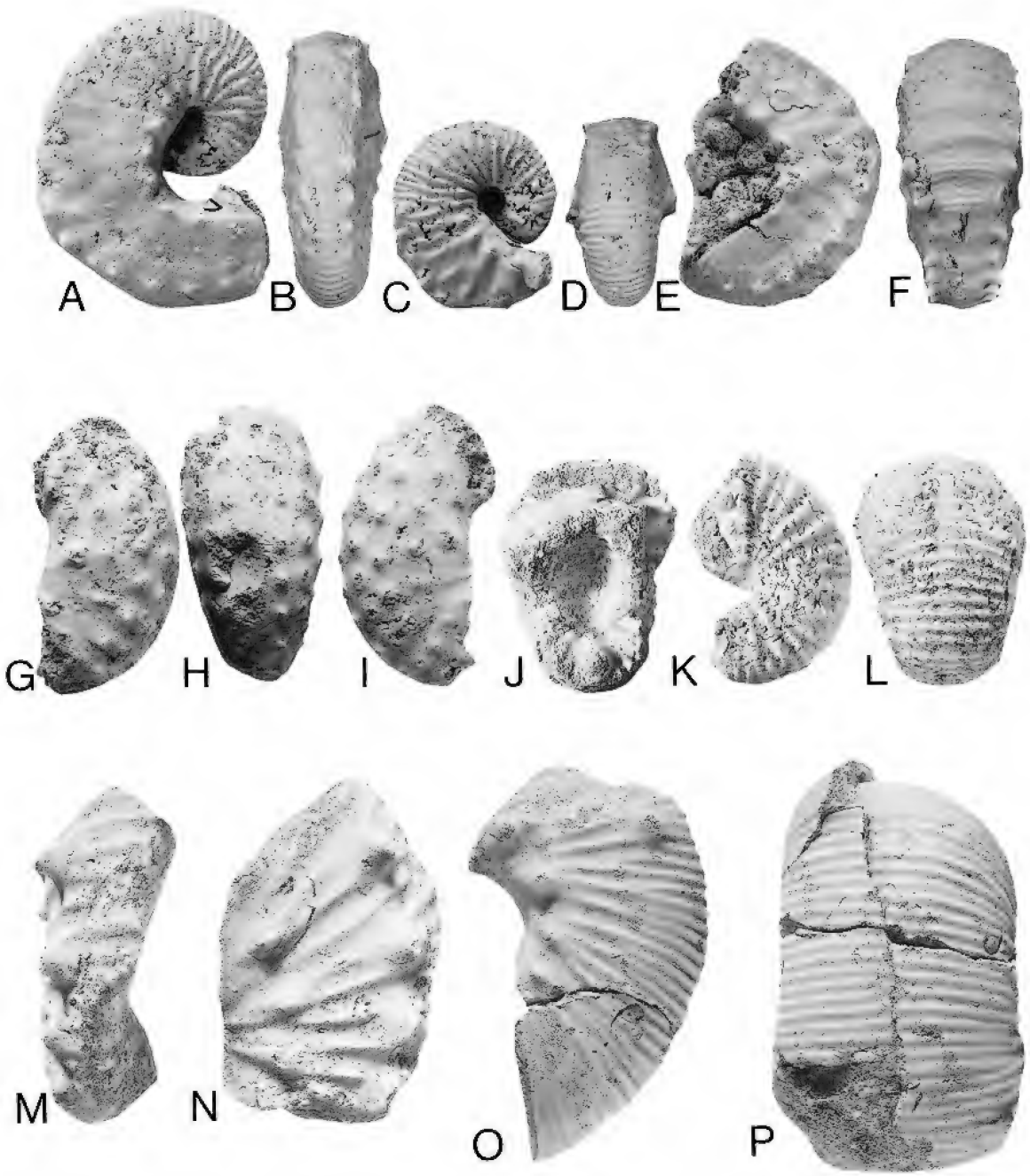


Fig. 9. **A–F.** *Hoploscaphites pumilus* (Stephenson, 1941). **A, B.** MAPS 2032a1; **C, D.** MAPS 2032a2; **E, F.** MAPS 2032a3; **G–I.** *Discoscaphites gulosus* (Morton, 1834), NJSM 16121, Inversand Pit, Sewell, Gloucester County, New Jersey. **J–P.** *Jeletzkytes* cf. *J. nodosus* (Owen, 1852). **J–L.** MAPS A2020a3; **M, N.** MAPS A2020a5; **O, P.** MAPS A2020a4. All specimens are from the lower phosphatic layer, Navesink Formation, Atlantic Highlands, unless otherwise stated. All figures are ×1.

Hoploscaphites pumilis (sic) Stephenson, 1941, Kennedy, 1986c: 1018, pl. 5, figs. 18–20.
Hoploscaphites pumilis (sic) Stephenson, 1941, Kennedy and Cobban, 1993: 426, figs. 9.3, 9.6, 12.5, 16.1–16.26, 17.1–17.21.
Hoploscaphites pumilus (Stephenson, 1941), Kennedy et al., 1995: pl. 6, figs. 1, 2.

TYPE: The holotype, by original designation, is USNM 21041, the original of Stephenson, 1941: pl. 90, figs. 10–12, from the Nacatoch Sand in the vicinity of Chatfield, Navarro County, Texas.

DESCRIPTION: MAPS A2032a1 (fig. 9A, B) is the most complete specimen. It is a microconch 44.0 mm long. The phragmocone is fairly involute with a small, deep umbilicus. The whorl section at the ultimate septum is compressed (ratio of whorl breadth to whorl height is 0.74), with the greatest breadth at the umbilical shoulder. Primary ribs arise at the umbilical seam and strengthen across the umbilical wall. The ribs are straight and prorsiradiate on the inner flanks and increase by branching and intercalation on the outer flanks. All ribs are equally strong on the venter. Umbilicolateral and ventrolateral tubercles develop on the adoral part of the phragmocone. The body chamber is compressed (ratio of whorl breadth to whorl height at mid-shaft is 0.84) with a steep umbilical wall and nearly flattened flanks that converge to a broadly rounded venter. The flanks are covered with broad, poorly defined ribs. There are five umbilicolateral tubercles. The ventrolateral tubercles become stronger and more clavate on the adoral part of the shaft but weaken on the final hook.

DISCUSSION: These specimens supplement material described by Cobban (1974a). Tubercles are absent on the inner whorls of the phragmocone but develop on the outer whorls. This is a feature of the holotype, but is not visible on Stephenson's figures. Small specimens differ in no significant respects from *Discoscaphites erucoides* Stephenson, 1941 (p. 429, pl. 91, figs. 2–4), which is here regarded as a synonym.

OCCURRENCE: Upper Campanian; lower phosphatic layer, basal part of Navesink Formation, Atlantic Highlands, New Jersey; Saratoga Chalk, Arkansas; Nacatoch Sand, Navarro County, Texas; Marnes de Plagne, Paillon, Haute Garonne, France; and Tercis, Landes, France.

Genus *Jeletzkytes* Riccardi, 1983

TYPE SPECIES: *Scaphites nodosus* Owen, 1852 (p. 581, pl. 8, fig. 4, by original designation).

Jeletzkytes cf. *J. nodosus* (Owen, 1852)

Figures 9J–P, 10, 11, 12C–F

compare:

Scaphites (*Ammonites*) *nodosus* (N.S.) Owen, 1852: 581, pl. 8, fig. 4.
Jeletzkytes cf. *J. nodosus* (Owen, 1852), Kennedy et al., 1995: pl. 6, fig. 3.

DESCRIPTION: MAPS A2020a1 (fig. 10) is a large, nearly complete macroconch body chamber 116 mm long. It has a pronounced umbilical bulge. There are 11 umbilicolateral bullae and 7 much larger ventrolateral clavi. The ribs are strong and widely spaced and cross the venter with an adoral projection.

MAPS A2020a2 (fig. 11) is a large, well-preserved microconch, 89.2 mm in maximum length; the adoral portion of the hook is missing. The phragmocone is robust with a ratio of whorl breadth to whorl height of 1.33 at the ultimate septum. There is a deep umbilicus with a steep umbilical wall and a sharply rounded umbilical shoulder. The whorl section of the phragmocone is subquadrate with broadly rounded flanks, sharply rounded ventrolateral shoulders, and a broadly rounded venter. Strong primary ribs arise on the umbilical wall and are rectiradiate on the flanks. They bear strong umbilicolateral bullae. Single ribs link these bullae to equally prominent ventrolateral tubercles. Two or three ribs loop between ventrolateral tubercles on either side of the venter. One or two equally strong nontuberculate ribs intercalate between these groups. All ribs cross the venter with a broad convexity.

The body chamber is robust with a ratio of whorl breadth to whorl height of 1.25 at mid-shaft. The umbilical seam is concave in lateral view. The whorl section is subquadrate with broadly rounded flanks, sharply rounded ventrolateral shoulders, and a broadly rounded venter. Strong primary ribs are prorsiradiate on the inner flanks and bear

Fig. 10. *Jeletzkytes* cf. *J. nodosus* (Owen, 1852), MAPS A2020a1, macroconch, lower phosphatic level, Navesink Formation, Atlantic Highlands, New Jersey. Both figures are ×1.

Fig. 11. *Jeletzkytes* cf. *J. nodosus* (Owen, 1852), MAPS A2020a2, microconch, lower phosphatic level, Navesink Formation, Atlantic Highlands, New Jersey. All figures are ×1.

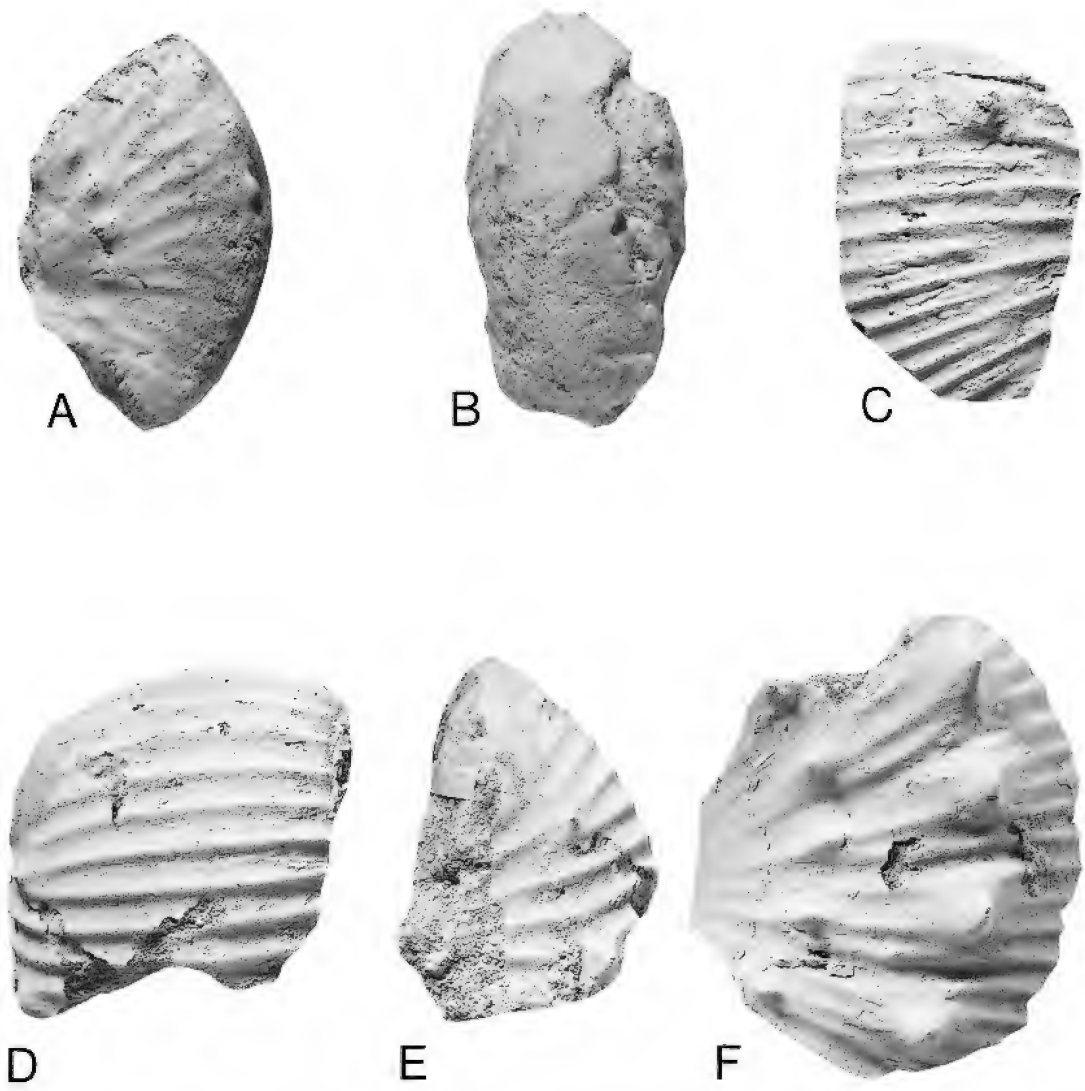


Fig. 12. **A, B.** *Jeletzkytes criptonodosus* Riccardi, 1983, MAPS A2050a1, Navesink Formation, bank of Nut Swamp Brook, near Middletown, Monmouth County. **C–F.** *Jeletzkytes* cf. *J. nodosus* (Owen, 1852), lower phosphatic layer, Navesink Formation, Atlantic Highlands, New Jersey. **C.** USNM 445247; **D, E.** MAPS A2020a6; **F.** MAPS A2020a7. All figures are ×1.

sharp umbilicolateral tubercles. These tubercles give rise to pairs of ribs that increase by intercalation on the outer flanks. There are six ventrolateral tubercles on the preserved part of the body chamber. They become increasingly stronger and more clavate in an adoral direction. Groups of three ribs loop between ventrolateral tubercles on either side of the venter with one equally strong nontuberculate rib between these groups. All ribs cross the venter with a broad convexity.

MAPS A2020a4 (fig. 9 O, P) is the final hook of the body chamber of a microconch. It has a concave umbilical wall and depressed, reniform whorl section (ratio of whorl breadth to whorl height is 1.38, accentuated by crushing). Four small, sharp bullae perch just outside the umbilical shoulder, and give rise to narrow sharp primary ribs in groups of three. At the adapical end of the fragment two of these ribs loop to a ventrolateral tubercle, but for most of the fragment,

the ribs loop across the venter to umbilicolateral bullae on the other side, with some intercalated ribs arising at the ventrolateral shoulder, such that there is dense even ventral ornament.

MAPS A2020a7 (fig. 12F) is a fragment of a large body chamber with well-preserved flank ornament consisting of looped and intercalated ribs, and subspinose umbilicolateral and ventrolateral nodes.

DISCUSSION: The holotype of *Jeletzkytes nodosus* (Owen, 1852) (p. 581, pl. 8, fig. 4) is a macroconch that is finer ribbed than the present material, which can be matched, however, in other material from the Pierre Shale of the U.S. Western Interior. USNM 182522 (Cobban, 1974a: pl. 11, figs. 13, 14) differs from the present specimens in having many more ventrolateral tubercles on the phragmocone. Until the status of *J. nodosus* is resolved on the basis of the abundant material from the U.S. Western Interior, we refer the New Jersey specimens to *Jeletzkytes* cf. *J. nodosus*. The relationship with *Acanthoscaphites praequadrispinosus* Błaszkiewicz, 1980 (p. 38, pl. 19, figs. 2, 3, 6–8, pl. 20, figs. 1–3, 6–8, pl. 21, figs. 1–6) also bears further scrutiny.

OCCURRENCE: *Jeletzkytes* cf. *J. nodosus* is known from the lower phosphatic layer, basal Navesink Formation, Atlantic Highlands, New Jersey. Similar specimens are reported from the Coon Creek Tongue of the Ripley Formation in Tennessee; Saratoga Chalk, Arkansas; Nacatoch Sand, Chatfield County, northeast Texas; *Baculites reesidei* and *B. jenseni* zones, U.S. Western Interior; and the Vistula Valley, Poland.

Jeletzkytes cf. *J. plenus* (Meek, 1876)

Figure 13

compare:

Scaphites nodosus, var. *plenus* Meek, 1876: 429, pl. 26, figs. la–c.

DESCRIPTION: USNM 455380 (fig. 13) is a plaster cast of a large macroconch with a phragmocone 65 mm in diameter (the original specimen is lost). The whorl section of the phragmocone is slightly compressed with broadly rounded flanks and a broadly arched venter. Primary ribs arise on the umbilical wall and strengthen across the inner flanks of the phragmocone, where they bear small bullate umbilicolateral tubercles. Each of these tubercles gives rise to one or two straight, prorsiradiate ribs; other ribs intercalate both high and low on the flanks. Single ribs or pairs of ribs link the umbilicolateral tubercles to 11 or 12 much stronger clavate ventrolateral tubercles on the last half-whorl of the phragmocone. Groups of two or three narrow ribs loop between the ventrolateral tubercles and cross the venter in a broad convexity, while one or two nontuberculate ribs of equal strength intercalate between the tuberculate groups.

The body chamber is incomplete, but its estimated complete length is 110 mm; it is slightly higher than wide (ratio of whorl breadth to whorl height at mid-shaft is 0.92). The umbilical wall is convex and the umbilical shoulder is straight in profile, so that most of the umbilicus of the spire is occluded. The inner flanks are broadly rounded, the outer flanks are flattened and convergent, and the venter is broadly rounded. Strong, distant, narrow prorsiradiate ribs arise on the umbilical wall; they are feebly concave across the umbilical shoulder and markedly prorsiradiate and concave on the flanks. Five strong umbilicolateral bullae are present on the shaft, and two weaker ones are present on the first part of the final hook (the rest of the body chamber is missing). Groups of two or three ribs link these bullae to much stronger clavate ventrolateral tubercles, with one to three nontuberculate ribs, some of them long intercalaries, between the tuberculate groups. An estimated 10 ventrolateral tubercles were present on the complete body chamber. Groups of two or three weakly convex ribs loop across the venter between ventrolateral tubercles, and are separated by one or two nontuberculate ribs.

DISCUSSION: This specimen differs from the holotype of *Jeletzkytes plenus* in being more compressed and more coarsely ribbed. *J. plenus* occurs in the *Baculites eliasi* and *B. baculus* zones in the Western Interior of the United States. Until the taxonomy of *J. plenus* is resolved on the basis of the abundant material from the U.S. Western Interior, we refer this specimen to *J.* cf. *J. plenus*.

OCCURRENCE: ?Upper phosphatic layer,

Fig. 13. *Jeletzkytes* cf. *J. plenus* (Meek, 1876), USNM 455380, cast (original specimen is lost), macroconch, ?upper phosphatic level, Navesink Formation, Atlantic Highlands, New Jersey. All figures are ×1.

basal Navesink Formation, Atlantic Highlands, New Jersey.

Jeletzkytes criptonodosus Riccardi, 1983
Figure 12A, B

Jeletzkytes criptonodosus Riccardi, 1983: 28, pl. 6, fig. 10, pl. 7, figs. 1, 2, pl. 8, figs. 7–9, text-figs. 25–27.
Jeletzkytes cf. *criptonodosus* Riccardi, 1983: 30, pl. 11, figs. 1–21, text-figs. 28–31.
Jeletzkytes criptonodosus Riccardi, 1983, Cobban and Kennedy, 1995: 31, figs. 6.4, 6.5, 22.5–22.12, 23.1–23.5.
Jeletzkytes criptonodosus Riccardi, 1983, Larson et al., 1997:81.

TYPE: The holotype is GSC 67104, from the Belanger Member of the Bearpaw Formation of Saskatchewan, Canada (Riccardi, 1983: pl. 6, fig. 10, pl. 7, figs. 1, 2).

DESCRIPTION: MAPS A2050a1 (fig. 12A, B) is a fragment with a maximum preserved whorl height of 35.5 mm; it is from the adapical end of the body chamber, and shows part of the final septum. A feeble umbilical bulge suggests that it is a small macroconch. The whorl section is compressed, with broadly rounded inner flanks, flattened, convergent outer flanks, and a broadly arched venter. There are six small umbilicolateral bullae, each of which gives rise to two or three narrow, delicate, prorsiradiate, weakly convex primary ribs that loop and zig-zag between small ventrolateral clavi. The poorly preserved venter is smooth to very feebly ribbed.

DISCUSSION: This fragment compares well with specimens of *Jeletzkytes criptonodosus* in the USGS collections from the *Baculites grandis* zone of the U.S. Western Interior as well as with the Canadian paratype figured by Riccardi (1983) as his pl. 8, figs. 7, 8 from the *B. baculus* zone of the southern part of the Canadian Western Interior.

OCCURRENCE: Lower Maastrichtian; middle part of Navesink Formation, from the oyster conglomerate, at Nut Swamp Brook, Middletown, Monmouth County, New Jersey; *Baculites baculus* zone in the Canadian Western Interior; *Baculites grandis* zone in the U.S. Western Interior; Prairie Bluff Chalk in Alabama; and Ripley Formation in Mississippi.

Genus *Discoscaphites* Meek, 1870

TYPE SPECIES: *Ammonites Conradi* Morton, 1834 (p. 39, pl. 16, fig. 3, by original designation).

Discoscaphites gulosus (Morton, 1834)
Figure 9G–I

Ammonites Conradi var. (A) *gulosus* Morton, 1834: 39, pl. 16, fig. 2.
Scaphites gulosus (Morton), Owen, 1852: 578.
Scaphites (*Discoscaphites*) *conradi* var. *gulosus* (Morton), Meek, 1876: 432, pl. 36, fig. 1.
Discoscaphites conradi var. *gulosus* (Morton), Reeside, 1927: 29.
Discoscaphites gulosus (Morton), Landman and Waage, 1993: 212, figs. 156, 157, 159, 160, 167–180 (with full synonymy).
Discoscaphites gulosus (Morton, 1834), Cobban and Kennedy, 1995: 29, figs. 10.4, 10.5, 19.20–19.24, 20.2, 20.8–20.12, 20.14–20.17, 21.18–21.21.

TYPE: The holotype is ANSP 51552, from the Prairie Bluff Chalk at Prairie Bluff, Alabama.

DESCRIPTION: NJSM 16121 (fig. 9G–I) is most of a stout adult body chamber 42.0 mm long with a whorl height of 20.4 mm. Only one side is preserved. The flank is flattened and the venter is broadly rounded. The ornament comprises five equally spaced rows of small, round tubercles located on low, poorly defined, very weak ribs.

DISCUSSION: This specimen is part of a small macroconch that resembles those illustrated by Landman and Waage (1993) from the Fox Hills Formation of South Dakota.

OCCURRENCE: This specimen was collected from a spoil pile of the Navesink Formation at the Inversand Pit at Sewell, Gloucester County, New Jersey. It could be from a lag deposit above the Navesink Formation, but its state of preservation is characteristic of Navesink fossils. The species is known elsewhere from the Upper Maastrichtian Severn Formation in Maryland, the Prairie Bluff Chalk in Alabama, the Corsicana Formation in Texas, and the *Hoploscaphites nicolletii* and *Jeletzkytes nebrascensis* zones of the Fox Hills Formation in South Dakota.

ACKNOWLEDGMENTS

We are particularly grateful to H. Mendryk (New York, New York) who donated many

fine specimens for study and whose pioneering work at Atlantic Highlands helped make this study possible. W. C. Rudderow (Clarksburg, New Jersey) provided invaluable assistance in the field. W. B. Gallagher (Trenton, New Jersey) loaned us important Navesink ammonites in the New Jersey State Museum. A. Szatmary (South Amboy, New Jersey) provided the specimen of *Eubaculites* cf. *E. labyrinthicus*. R. L. Hall (Calgary), C. W. Wright (Seaborough, Dorset), W. B. Gallagher, and K. Tanabe (Tokyo) reviewed an early version of this manuscript. Kennedy acknowledges the financial support of the Natural Environment Research Council (UK) and staff of the Geological Collections, University Museum, Oxford, and Department of Earth Sciences, Oxford. Landman thanks S. Klofak and K. Sarg (both AMNH) for assistance in the field. Also at AMNH, J. Beckett and P. Rollings photographed several of the specimens and S. Crooms word-processed the manuscript. The U.S. Geological Survey provided additional material for study.

REFERENCES

Błaszkiewicz, A.
1980. Campanian and Maastrichtian ammonites of the Middle Vistula Valley, Poland: a stratigraphic-paleontologic study. Prace Inst. Geol. 92: 1–63.

Brunnschweiler, R. O.
1966. Upper Cretaceous ammonites from the Carnavon basin of western Australia; [pt.] 1. The heteromorph Lytoceratina. Bur. Miner. Resour. Geol. Geophys. Bull. (Canberra) 58: 58 pp.

Bürgl, H.
1955. La Formación Guadalupe entre Tabio y Chía en la Sabana de Bogotá. Bol. Inst. Geol. Nac. (Bogota) 3: 23–55.
1957. Biostratigrafia de la Sabana de Bogota y Alrededores. Ibid. 5: 113–185.

Cobban, W. A.
1974a. Ammonites from the Navesink Formation at Atlantic Highlands, New Jersey. U.S. Geol. Surv. Prof. Pap. 845: 21 pp.
1974b. Some ammonoids from the Ripley Formation of Mississippi, Alabama, and Georgia. U.S. Geol. Surv. J. Res. 2: 81–88.

Cobban, W. A., and W. J. Kennedy
1991. Upper Cretaceous (Maastrichtian) ammonites from the *Nostoceras alternatum* zone in southwestern Arkansas. U.S. Geol. Surv. Bull. 1985: E1–E6.
1995. Maastrichtian ammonites chiefly from the Prairie Bluff Chalk in Alabama and Mississippi. Paleontol. Soc. Mem. 44: 40 pp.

Collignon, M.
1971. Atlas des fossiles caractéristiques de Madagascar (Ammonites); XVII (Maestrichtien). Tananarive: Service Géologique, 44 pp.

Conrad, T. A.
1855. Descriptions of eighteen new Cretaceous and Tertiary fossils, etc. Proc. Acad. Nat. Sci. Philadelphia 7: 265–268.
1860. Descriptions of new species of Cretaceous and Eocene fossils of Mississippi and Alabama. J. Acad. Nat. Sci. Philadelphia 4: 275–298.

Diener, C.
1925. Ammonoidea neocretacea. Fossilium Cat. (1:Animalia) 29: 244 pp.

Favre, E.
1869. Description des mollusques fossiles de la Craie des environs de Lemberg en Galicie. Geneva: H. Georg, 187 pp.

Forbes, E.
1846. Report on the fossil Invertebrata from southern India, collected by Mr. Kaye and Mr. Cunliffe. Trans. Geol. Soc. London 7: 97–174.

Gabb, W.
1861a. A revision of the species of *Baculites*, described in Dr. Morton's "Synopsis of the Cretaceous group of the United States." Proc. Acad. Nat. Sci. Philadelphia 1861: 394–396.
1861b. Synopsis of the Mollusca of the Cretaceous Formation, including the geographical and stratigraphical range and synonymy. Proc. Am. Philos. Soc. 8: 57–257.

Gallagher, W. B.
1984. Paleoecology of the Delaware Valley region, part 2, Cretaceous to Quaternary. Mosasaur 2: 9–43.
1992. Geochemical investigations of the Cretaceous/Tertiary boundary in the Inversand Pit, Gloucester County, New Jersey. N.J. Acad. Sci. Bull. 37: 19–24.
1993. The Cretaceous/Tertiary mass extinction event in the northern Atlantic Coastal Plain. Mosasaur 5: 75–154.

Gill, T.
1871. Arrangement of the families of Mollusks. Smithson. Misc. Collect. 227: 49 pp.

Grabau, A. W., and H. W. Shimer
1910. North American index fossils: invertebrates, 2. New York: A. G. Seiler, 909 pp.
Grossouvre, A. de
1894. Recherches sur la craie supérieure, 2, Paléontologie. Les ammonites de la Craie supérieur. Mém. Serv. Carte Géol. Dét. France: 264 pp. (misdated 1893).
Haas, O.
1943. Some abnormally coiled ammonites from the Upper Cretaceous of Angola. Am. Mus. Novitates 1222:17 pp.
Hancock J. M., and W. J. Kennedy
1993. The high Cretaceous ammonite fauna from Tercis, Landes, France. Bull. Inst. R. Sci. Nat. Belgique 63: 149–209.
Hauer, F. von
1858. Über die Cephalopoden aus der Gosauschichten. Beitr. Paläontol. Oesterr. 1: 7–14.
Henderson, R. A., and K. A. McNamara
1985. Maastrichtian non-heteromorph ammonites from the Mira Formation, Western Australia. Palaeontology 28: 35–88.
Hupsch, J.W.C.A.
1768. Neue in der Naturgeschichte des Niederdeutschlands gemachte Entdeckungen einiger seltenen und wenig bekannten versteinerten Schaaltheire. Frankfurt: Der Metternichischen Buchhandlung, 159 pp.
Hyatt, A.
1889. Genesis of the Arietidae. Smithson. Contrib. Knowl. 673: 239 pp.
1894. Phylogeny of an acquired characteristic. Proc. Am. Philos. Soc. 32: 349–647.
1900. Cephalopoda. *In* K. A. von Zittel (ed.), Textbook of palaeontology, transl. C. R. Eastman: 502–604. London: Macmillan, 1896–1900.
Kennedy, W. J.
1986a. Campanian and Maastrichtian ammonites from northern Aquitaine, France. Spec. Pap. Palaeontol. 36: 145 pp.
1986b. The ammonite fauna of the Calcaire à *Baculites* (upper Maastrichtian) of the Cotentin Peninsula (Manche, France). Palaeontology 29: 25–83.
1986c. Systematic paleontology. *In* W. J. Kennedy, M. Bilotte, B. Lepicard, and F. Segura (eds.), Upper Campanian and Maastrichtian ammonites from the Petites-Pyrénées, southern France. Eclogae Geol. Helv. 79: 1001–1037.
1987. The ammonite fauna of the type Maastrichtian with a revision of *Ammonites colligatus* Binkhorst, 1861. Bull. Inst. R. Sci. Nat. Belgique 56: 151–267 (misdated 1986).
1989. Thoughts on the evolution and extinction of Cretaceous ammonites. Proc. Geol. Assoc. 100: 251–279.
Kennedy, W. J., and W. K. Christensen
1997. Santonian to Maastrichtian ammonites from Scania, southern Sweden. Fossils Strata 44: 75–128.
Kennedy, W. J., and W. A. Cobban
1993. Ammonites from the Saratoga Chalk (Upper Cretaceous), Arkansas. J. Paleontol. 67: 404–434.
Kennedy, W. J., and J. M. Hancock
1993. Upper Maastrichtian ammonites from the Marnes de Nay between Gan and Rébénacq (Pyrénées-Atlantiques), France. Geobios 26: 575–594.
Kennedy, W. J., and R. A. Henderson
1992. Non-heteromorph ammonites from the Upper Maastrichtian of Pondicherry, South India. Palaeontology 35: 381–442.
Kennedy, W. J., and H. C. Klinger
1977. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite family Tetragonitidae Hyatt, 1900. Ann. S. Afr. Mus. 73: 149–197.
Kennedy, W. J., and H. Summesberger
1986. Lower Maastrichtian ammonites from Neuberg, Steiermark, Austria. Beitr. Paläontol. Oesterr. 12: 181–242.
Kennedy, W. J., R. O. Johnson, and W. A. Cobban
1995. Upper Cretaceous ammonite faunas of New Jersey. *In* J.E.B. Baker (ed.), Contributions to the paleontology of New Jersey 12: 24–55. Geol. Assoc. New Jersey.
Klinger, H. C.
1976. Cretaceous heteromorph ammonites from Zululand. Mem. Geol. Surv. S. Afr. 69: 142 pp.
Kossmat, F.
1895–1898. Untersuchungen über die Südindische Kreideformation. Beitr. Paläontol. Öst.-Ung. Orients 9 (1895): 97–203 (1–107); 11 (1897): 1–46 (108–153); 11 (1898): 89–152 (154–217).
Kullmann, J., and J. Wiedmann
1970. Significance of sutures in phylogeny of Ammonoidea. Univ. Kansas, Paleontol. Contrib. 44: 1–32.
Lamarck, J.P.B.A. de M. de
1799. Prodrome d'une nouvelle classification des coquilles. Mém. Soc. Hist. Nat. Paris 1: 63–91.
1801. Système des animaux sans vertèbres. J.P.B.A. de Lamarck, Paris, 432 pp.

Landman, N. H., and K. M. Waage
1993. Scaphitid ammonites of the Upper Cretaceous (Maastrichtian) Fox Hills Formation in South Dakota and Wyoming. Bull. Am. Mus. Nat. Hist. 215: 257 pp.

Larson, N. L., S. D. Jorgensen, R. A. Farrar, and P. L. Larson
1997. Ammonites and the other cephalopods of the Pierre Seaway. An identification guide. Tucson, AZ: Geoscience Press, 148 pp.

Lewy, Z.
1969. Late Campanian heteromorph ammonites from southern Israel. Israel J. Earth Sci. 18: 109–135.

Matsumoto, T.
1977. Some heteromorph ammonites from the Cretaceous of Hokkaido. Mem. Fac. Sci. Kyushu Univ. Ser. D Geol. 23: 303–366.

Meek, F. B.
1870. A preliminary list of fossils, collected by Dr. Hayden in Colorado, New Mexico, and California, with brief descriptions of a few of the new species. Proc. Am. Philos. Soc. 11: 425–431.
1876. A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. U.S. Geol. Surv. Territ. (Hayden) Rep. 9: 629 pp.

Meek, F. B., and F. V. Hayden
1856. Descriptions of new species of Gastropoda and Cephalopoda from the Cretaceous formations of Nebraska Territory. Proc. Acad. Nat. Sci. Philadelphia 8: 70–72.

Miller, K. G., E. Barrera, R. K. Olsson, P. J. Sugarman, and S. M. Savin
1999. Does ice drive early Maastrichtian eustasy? Geology 27: 785–786.

Minard, J. P.
1969. Geology of the Sandy Hook quadrangle in Monmouth County, New Jersey. U.S. Geol. Surv. Bull. 1276: 43 pp.

Morton, S. G.
1834. Synopsis of the organic remains of the Cretaceous group of the United States. Illustrated by nineteen plates, to which is added an appendix containing a tabular view of the Tertiary fossils hitherto discovered in North America. Philadelphia: Key and Biddle, 88 pp.
1841. Description of several new species of fossil shells from the Cretaceous deposits of the United States. Proc. Acad. Nat. Sci. Philadelphia 1: 106–110.

Nowak, J.
1911. Untersuchungen über die Cephalopoden der oberen Kreide in Polen. II. Teil. Die Skaphiten. Bull. Acad. Sci. Cracovie. Cl. Sci. Math. Nat. Sér. B Sci. Nat. 1911: 547–589.

Odin, G.
1996. Definition of a global boundary stratotype section and point for the Campanian/Maastrichtian boundary. Bull. Inst. R. Sci. Nat. Belgique 66-Suppl.: 111–117.

Olsson, R. K.
1988. Foraminiferal modelling of sea-level change in the Late Cretaceous of New Jersey. S.E.P.M. Spec. Publ. 42: 289–297.

Orbigny, A. d'
1847. Paléontologie, plates 1–6 (Géologie plates 4–9 [no text]). *In* M. Dumont d' Urville. 1846–1854. Voyage au Pôle Sud et dans l'Océanie sur les corvelles L'Astrolabe et la Zélée pendant les années 1837–1838–1839–1840 sous le commandément de M. Dumont d'Urville Capitaine du Vaisseau. Paris: Gide and J. Baudry, Imprimérie de J. Claye et Cie, 1846–1854, 9 pls. [no text].

Owen, D. D.
1852. Report of a geological survey of Wisconsin, Iowa, and Minnesota, and incidentally a portion of Nebraska Territory. Philadelphia: Lippincott, Grambo, 638 pp.

Owens, J. P., J. P. Minard, N. F. Sohl, and J. F. Mello
1970. Stratigraphy of the outcropping post-Magothy Upper Cretaceous formations in southern New Jersey and northern Delmarva Peninsula, Delaware and Maryland. U.S. Geol. Surv. Prof. Pap. 674: 60 pp.

Prather, J. K.
1905. The Atlantic Highlands section of the New Jersey Cretacic. Am. Geologist 36: 162–178.

Rawson, P. F., A. V. Dhont, J. M. Hancock, and W. J. Kennedy
1996. Proceedings, Second International Symposium on Cretaceous Stage Boundaries, Brussels, 8–16 Sept. 1995. Bull. Inst. R. Sci. Nat. Belgique Sci. Terre 66-Suppl.: 117 pp.

Reeside, J. B., Jr.
1927. The scaphites, an Upper Cretaceous ammonite group. U.S. Geol. Surv. Prof. Pap. 150-B: 21–40.

Riccardi, A. C.
1983. Scaphitids from the Upper Campanian-Lower Maastrichtian Bearpaw Formation of the western interior of Canada. Geol. Surv. Can. Bull. 354: 51 pp.

Richards, H. G.
1956. Geology of the Delaware Valley. Phildelphia: Mineralogical Society of Pennsylvania, 106 pp.

Roman, F.
1938. Les ammonites jurassiques et crétacées. Essai de genera. Paris: Masson, 554 pp.

Say, T.
1820. Observations on some species of zoophytes, shells, etc., principally fossil. Am. J. Sci. (1) 2: 34–35.

Shigeta, Y.
1992. A record of *Pseudophyllites indra* (Lytoceratina, Tetragonitidae) from the Upper Cretaceous of Hokkaido and Sakhalin. Trans. Proc. Palaeontol. Soc. Japan, New Ser. 166: 1157–1163.

Shumard, B. F.
1861. Descriptions of new Cretaceous fossils from Texas. Proc. Boston Soc. Nat. Hist. 8: 188–205.

Sowerby, J.
1817. The mineral conchology of Great Britain, 2: pls. 151–184, A. London: The author.

Spath, L. F.
1922. On the Senonian ammonite fauna of Pondoland. Trans. R. Soc. S. Afr. 10: 113–147.
1926. On new ammonites from the English Chalk. Geol. Mag. 63: 77–83.

Stephenson, L. W.
1941. The larger invertebrates of the Navarro Group of Texas (exclusive of corals and crustaceans and exclusive of the fauna of the Escondido Formation). Univ. Tex. Bull. 4101: 641 pp.

Stinnesbeck, W.
1986. Zu den faunistischen und palökologischen Verhältnissen in der Quiriquina Formation (Maastrichtian) Zentral-Chiles. Palaeontographica Abt. A 194: 99–237.

Stoliczka, F.
1863–1866. The fossil Cephalopoda of the Cretaceous rocks of southern India. Ammonitidae with revision of the Nautilidae etc. Mem. Geol. Surv. India. (1), Palaeontol. Indica 3. (1): 41–56 (1863); (2–5): 57–106 (1864); (6–9): 107–154 (1865); (10–13): 155–216 (1866).

Sugarman, P. J., K. G. Miller, D. Bukry, and M. D. Feigenson
1995. Uppermost Campanian-Maestrichtian strontium isotopic, biostratigraphic, and sequence stratigraphic framework of the New Jersey Coastal Plain. Geol. Soc. Am. Bull. 107: 19–37.

Tuomey, M.
1854. Description of some new fossils from the Cretaceous rocks of the Southern States. Proc. Acad. Nat. Sci. Philadelphia 7: 167–172.

Vasicek, Z.
1988. Die Oberkreide—Ammoniten (Maastricht) aus dem Abteufen des Keinzichschachts der Grub Stărič (Unterschlesian Decke, Äussere-Karpaten). Acta Mus. Moraviae Sci. Nat. 73: 71–81.

Wade, B.
1926. The fauna of the Ripley Formation on Coon Creek, Tennessee. U.S. Geol. Surv. Prof. Pap. 137: 272 pp.

Ward, P. D., and W. J. Kennedy
1993. Maastrichtian ammonites from the Biscay region (France, Spain). Paleontol. Soc. Mem. 34: 58 pp.

Wedekind, R.
1916. Über Lobus, Suturallobus und Inzision. Zentbl. Min. Geol. Paläontol. 1916: 185–195.

Weller, S.
1907. A report on the Cretaceous paleontology of New Jersey, based upon the stratigraphic studies of George N. Knapp. Geol. Surv. New Jersey Paleontol. Ser. 4: 1–1107.

Whitfield, R. P.
1877. Preliminary report on the paleontology of the Black Hills, containing descriptions of new species of fossils from the Potsdam, Jurassic, and Cretaceous formations of the Black Hills of Dakota. U.S. Geog. Geol. Surv. Rocky Mt. Reg.: 49 pp.
1892. Gasteropoda and Cephalopoda of the Raritan clays and greensand marls of New Jersey. U.S. Geol. Sur. Monogr. 18: 402 pp.

Wiedmann, J.
1966. Stammesgeschichte und System der posttriadischen Ammonoideen; ein Überblick. Neues Jahrb. Geol. Paläontol. Abh. 125: 49–79; 127: 13–81.

Zittel, K. A. von
1884. Handbuch der Palaeontologie, v. 2. Munich: R. Oldenbourg, 893 pp.
1895. Grundzüge der Palaeontologie (Palaeozoologie). Ibid., 972 pp.

Recent issues of the *Novitates* may be purchased from the Museum. Lists of back issues of the *Novitates* and *Bulletin* published during the last five years are available at World Wide Web site http://nimidi.amnh.org. Or address mail orders to: American Museum of Natural History Library, Central Park West at 79th St., New York, NY 10024. TEL: (212) 769-5545. FAX: (212) 769-5009. E-MAIL: scipubs@amnh.org

♾ This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).